THE EAST MIDLAND GEOGRAPHER

DA
670
.M64
E13
no.7

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF NOTTINGHAM

No. 7. June, 1957 *Four Shillings*

UNIVERSITY OF MICHIGAN
GENERAL LIBRARY

Editorial Committee:
PROF. K. C. EDWARDS
DR. G. J. FULLER
MR. E. M. RAWSTRON
Editorial Secretary:
MISS M. BALL

CORRECTION

On page 23 substitute "Fig. 4" for "Fig. 3" and "1954" for "1939". On page 25 substitute "Fig. 3" for "Fig. 4" and "1939" for "1954".

This Journal is published in June and December each year and can be obtained from the Editorial Secretary, Department of Geography, The University, Nottingham. Price 4/6 post free.

CORRECTION

On page 23 substitute "Fig. 4" for "Fig. 3" and "1954" for "1939".
On page 25 substitute "Fig. 3" for "Fig. 4" and "1939" for "1954".

THE EAST MIDLAND GEOGRAPHER

CONTENTS

		Page
The Development of Drainage, Agriculture and Settlement in the Fens of South-East Lincolnshire during the 19th Century	*G. Joan Fuller*	3
The Agricultural Geography of Derbyshire in the Early 19th Century	*H. C. K. Henderson*	16
Industry in the Small Country Towns of Lincolnshire, Northamptonshire and Rutland	*Ian G. Weekley*	21
The Differentiation of the Glacial Drifts of the East Midlands	*K. M. Clayton*	31
Some Glacial Features of East Lincolnshire	*Allan Straw*	41
"The Valley", Ancaster : a Lincolnshire Overflow Channel ?	*D. R. Mills and K. Warren*	49
East Midland Record		52

The East Midlands Earthquake of February, 1957.
International Geographical Union Newsletter.
Geographical Association Conference at Matlock.

No. 7 JUNE 1957

DEVELOPMENT OF DRAINAGE, AGRICULTURE AND SETTLEMENT IN THE FENS OF SOUTH-EAST LINCS. DURING THE 19th CENTURY

G. Joan Fuller

Reclamation of marshland has been one of the most difficult and most rewarding tasks that man has undertaken in adapting the landscape to his use. It has been carried out at many different times and in many different places and so there is considerable diversity between these man-made landscapes. The contrast, for example, between Romney Marsh and the reclaimed islands of the San Joaquin delta in California, require both history and geography for their understanding. But one does not need to look so far afield to find reclaimed marshland whose landscape today invites a contrast with Romney Marsh. One such area lies in the south-east of Lincolnshire. It is the land of East, West and Wildmore Fens (Fig. 2).

At first sight, however, it is the similarities and not the differences between these two areas which strike the observer. The wide expanse of level land, sheltering behind sea defences and dissected by dykes, is the basic element in both landscapes. But to journey across these levels is to experience the contrasts between them. On Romney Marsh the traveller follows winding roads. He sees ancient churches standing in green fields where once there were villages. He admires the fine pastures close-cropped by Romney sheep. But the motorist who drives from Boston to the Wolds speeds along roads as straight as a ruler. He passes lines of red brick cottages, and now and again a Methodist chapel. He rarely sees a meadow. It is crops, not sheep, that meet the eye today.

Such contrasts are apparent to anyone. To the historical geographer they offer problems of great interest concerning both physical and human geography. This paper concerns itself with the less known of the two areas, the fens of south-east Lincolnshire. It analyses the development of drainage, agriculture and settlement during the period of greatest changes, viz. the 19th century. In order to do this it is necessary first of all to examine the basic physical geography of the area.

Physical Geography

The fens of south-east Lincolnshire are a small part of the great lowland basin surrounding the Wash and itself surrounded by Jurassic and Cretaceous scarplands. Their physical character and drainage problems are therefore similar to those of the Great (Bedford) Level. They are similar but not identical. There is for example, the problem of the rivers. The Lincolnshire fens have a large river, the Witham, flowing not through the centre of the fens as in the Great Level, but along their western margin. When its channel is adequate, it carries the "highland" water safely past the fens into the Wash. But when, as in the 18th century, its bed became silted, the Witham was a menace to Wildmore and West Fens. East Fen, too remote to suffer from the Witham floods, was frequently flooded by the Steeping river. Both these rivers therefore endangered the fens because of the "highland" water they carried, and neither served as a satisfactory outlet for the drainage of the fens themselves.

In addition to the "highland" water carried by the Witham and Steeping rivers, a certain amount from the southern Wolds discharged directly on to the fen by smaller streams draining the impervious boulder clays which cover much of the south-western Wolds. West Fen also received water from springs rising in the gravels along its northern border. This "highland" water was especially prone to flood the fen because of its rapid run-off down the cliff slope which overlooks the fen. It is worth noting also that the 1801 drainage act(1) states that this factor had become more serious since 1762, "Because of enclosures, embankments, and other improvements". Drainage engineers calculated that the amount of "highland" water draining daily into West and Wildmore Fens was sufficient to cover the 19,000 acres of low ground with 3/10″ of water in a day, and that in flood times three times that amount of water could be expected(2).

Clearly then these fens were the unfortunate recipients of much water from outside sources. In addition they faced problems in the disposal of their own rain water. At first sight these fens, lying in one of the driest areas of England, would seem more likely to suffer from droughts than floods. And drought is of course a problem. But records show that floods also occur. The Lade Bank Pumping Station records, available from 1875 onwards, show that while the average annual rainfall is only 22″, that average conceals a range from 35″ in 1880 to 13″ in 1921. Cycles too are recognisable, the 9 year wet period 1875-83 for example, being notable for a yearly average of 28″. A very significant factor also is the monthly distribution of rainfall. July and August are the wettest months, as much as 7.15″ being experienced in July, 1880. Thus the low average annual rainfall gives no indication of the sudden floods which may occur on these levels during thunderstorms. Such floods are of course critical for arable farming.

The rainfall of the fens therefore presents problems. Other contributory factors are the geological and relief conditions. The fens of south-east Lincolnshire are underlain by impermeable Kimmeridge Clays and the surface deposits particularly in West and Wildmore Fens consist mainly of medium and heavy silts. Thus conditions are unfavourable to natural drainage. And in East Fen where peats have accumulated, they form only a shallow deposit resting on clays. Geological conditions therefore make the fens into almost water-tight basins.

In discussing relief, it is worth emphasizing that in such landscapes significant features are not always obvious. To the naked eye the fens appear uniformly level. In fact they are not, neither are they all at the same height above the sea. In the first place there are two basins, not one, these being separated by a central ridge of boulder clay on which are sited the villages of Sibsey, Stickney, and Stickford. East of the ridge lies East Fen, west of it Wildmore and West Fens. As already mentioned, the two basins differ in surface deposits. They also differ in level, East Fen being generally lower than the western basin. A survey made in 1944 showed that the average level in East Fen was + 1′ above M.S.L. (Liverpool datum), and in West and Wildmore was + 5′. Thus the problem of draining East Fen was the more difficult. Nevertheless the fact that, with the exception of a small part of East Fen where a level of — 0·5′ was recorded, all these fens lie slightly above M.S.L., shows that gravity drainage is possible.

(1) 41 Geo. III, Cap. 135.
(2) Clarke, John A., "Farming of Lincs.", *Journal of Royal Agric. Soc.*, Vol. XII, 1851, p. 309.

Gravity drainage is possible, but not without man's assistance, because the higher siltlands, lying between the fens and the Wash, act as a barrier to the natural drainage. It is a low barrier, for the maximum height of the ridge between Boston and Wainfleet, is only about 12'. This is sufficient however to prevent Fen drainage from escaping directly to the Wash. Only by finding its way to the Witham or Steeping, could fen water in earlier times reach the sea. Furthermore the barrier has been reinforced by man in reclaiming the saltmarsh. Every foot of land gained from the Wash has entailed a reduction in the drainage gradient and lessened the efficiency of gravity drainage. Nevertheless south-east Lincolnshire is better situated in this respect than the Great Level, for the barrier is much narrower than in south Holland for example.

So far the discussion has been concerned with land water. But this was only half of the problem. The other half concerned the sea. It is important to realise that the whole of these fens is below high water level at Spring Tides. The second problem therefore has been to keep out the sea. This has been done by sea banks, but until sluices were constructed on the Witham, tide water flowed up the river unchecked and spread widely across the fens. Furthermore the sea banks themselves proved inadequate periodically, as in 1810 when the sea overrode them.

The Fens of South-east Lincolnshire in 1801

The next task is to examine briefly the human geography of the area in 1800, immediately prior to drainage. Figure 1 shows the population as recorded in the 1801 census. Certain basic contrasts stand out and are clearly related to physical conditions.

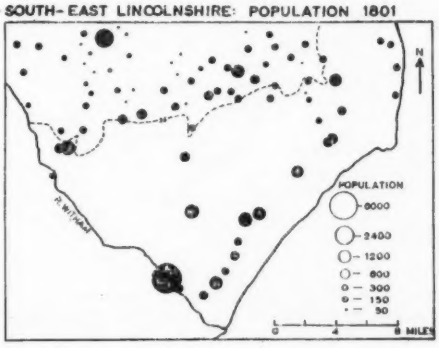

Fig. 1

In the north the southern Wolds were well populated with small villages, most of them of Scandinavian origin(1). There were also four market towns, Horncastle, Bolingbroke, Spilsby and Tattershall, together with Coningsby which had outgrown its neighbour Tattershall, but still ranked as a village. In the south a line of much larger villages spread along the higher silt lands. In 1800 these were prosperous farming communities, thriving on fertile loams and rich marsh pastures. At either end of the silt ridge was a market town, viz. Boston and Wainfleet. Both, however, were more important as ports than markets.

(1) See Bower, Irene M., *Place Names of Lindsey*, Unpublished Ph.D. Thesis, University of Leeds, 1940.

Boston, indeed, with a population of 5,926, was the largest town in the area and carried on a fair coasting trade despite the silting of the Witham estuary.

Between these two well populated areas lay the fens, empty of recorded settlement except for the villages on the central ridge. But were the fens in fact quite unpeopled? What indeed was the state of the Fens in 1800? Was permanent settlement possible within them? It is impossible to give a complete answer to these questions, but one can go some way towards it. Material is available, for example, on Armstrong's map of Lincolnshire in 1779, and from agricultural writers such as Arthur Young.

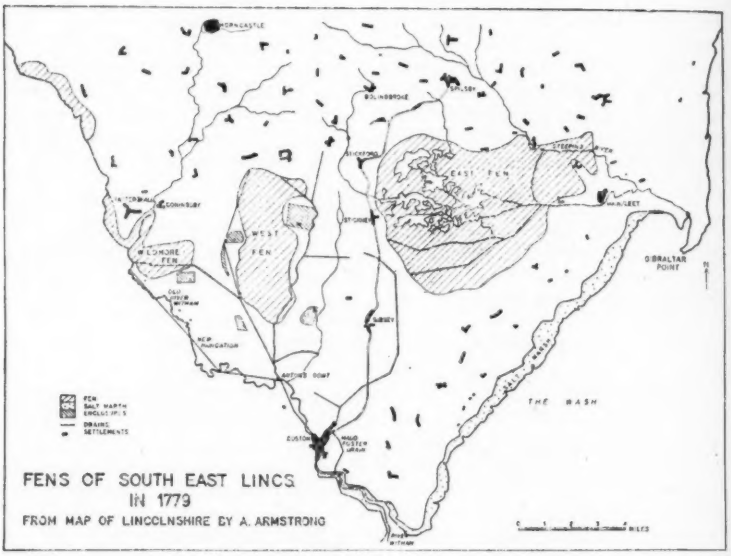

Fig. 2

NOTE: The fen boundaries as indicated by Armstrong did not include the whole area legally within the fen. They probably delimited the parts most frequently flooded.

Figure 2 shows that the differences between the eastern and western fen basins were far more apparent than they are today. The more low-lying East Fen, contained a large number of permanent lakes, the so-called "Deeps", surrounded by higher fens submerged only in winter. No enclosures nor houses can be seen. The area was then wholly common land shared between some 31 parishes on its northern, southern and western borders(1). The fact that the four parishes on its eastern (2) edge did not possess rights of common is of interest. Their boundaries ran into

(1) Unfortunately the parish boundaries for this period cannot be ascertained with certainty. Figure 3 indicates the settlements which had common rights in the fens.

(2) Wainfleet All Saints, Wainfleet St. Mary, Friskney and Wrangel.

the fen, enclosure having already taken place, not by individuals but on a parish basis. Thus the area legally known as East Fen was only a part of the geographical one. The parish of Friskney, for example, made good profits from its own fen, both from its decoys and its cranberry mosses. But neither in the common fen nor the enclosed fen was there appreciable settlement.

Armstrong's map shows clearly that the western fens were better drained. In spite of certain difficult areas such as "No Man's Friend" in West Fen, there were no permanent lakes. This was partly due to a better drainage gradient, and partly to more efficient drainage works. In spite of the attacks of the fen men, the Adventurers' drains had survived(1), and the drainage of the Witham fens carried out in the 1760's had embraced the whole of the western basin in its schemes. It is not surprising therefore to see that in these fens there were a few enclosures with houses. Nevertheless, most of the western fens were also held in common. Young's descriptions suggest that these better drained and more accessible fens were chiefly grazing lands, important for sheep, cattle, and horses, and still more for large flocks of geese. But Young noted also much land in poor condition, here covered with thistles, there overstocked.

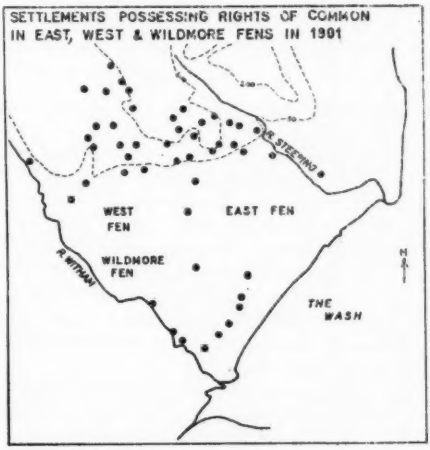

Fig. 3 (Scale as for Fig. 1).

The Drainage of the Fens after 1801

South-east Lincolnshire was one of the last areas of fen to be drained. That this was undertaken in the first years of the 19th century was a result in part of the general situation of agriculture. Grain was scarce and the price of corn was high and rising. The Lincolnshire fens could only turn to grain production, however, if drainage all the year round was adequate. And so the engineer Rennie was asked to submit plans which would enable the fens to be effectively drained and cultivated.

(1) Early reclamation was carried out between 1631 and '34 by Sir Anthony Thomas and a number of men who "adventured" capital for this purpose. The fen men destroyed most of the improvements.

His final scheme, embodied in the drainage acts of 1801 and 1803, was a contrast in some respects to Vermuyden's methods adopted in the Bedford Level. The most important difference was the separate provision for "highland" and lowland water. Instead of flowing unchecked into the fen, "highland" water was intercepted by catchwater drains (see Figure 4) following the northern fen margins and diverging south past the central ridge. In order to dispose of the lowland water, the original centrifugal trend of drainage, east to the Steeping or west to the Witham, was reversed. Gradients no longer favoured such outlets. The steepest gradient available was south to the Witham estuary, where discharge was possible for some hours each day around low tide. In the western basin, old drains were improved, new cuts made, and the water was conducted to the estuary at Maud Foster's Gout where a sluice was built to exclude the tides and regulate outfall. East Fen required more radical improvements. A main artery, the Hobhole Drain, was cut from north to south, fed by subsidiary drains from east and west, and Hobhole Sluice was built at the outfall.

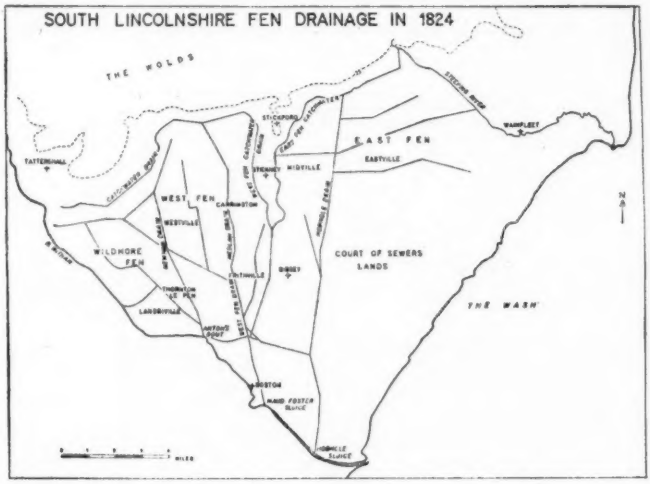

Fig. 4

Besides drainage, communications were improved. The drains were made large enough to allow the passage of river boats. Here we see a further advantage in the focussing of the drains on the estuary close to Boston. Both eastern and western basins now had convenient water access to Boston markets.

Enclosure and Settlement in the first half of the 19th Century

Cultivation of the drained fen necessitated the abandonment of common rights and the introduction of enclosure. Thus the drainage act of 1801 was closely followed by Acts for dividing and allotting the fens(1). The act for Wildmore provided for the enclosure of 10,500 acres.

(1) 41 Geo. III, Cap. 141, and 41 Geo. III, Cap. 142.

A significant provision was that all encroachments made during the previous 30 years were to be deemed part of the fen to be divided. Another point is that the ownership of the fen came into question. The Earl of Stamford as lord of the manor, claimed exclusive freehold rights, but this was contested by three other landowners. Evidently the prospects of enclosure made ownership economically significant for the first time. The act provided that 1/20 of the fen was to go to the lord of the manor, that other lands were to be sold to defray expenses, and that the remainder was to be divided between the parishes with common rights, according to the number of houses with common rights in each parish. In addition the surveyors were to lay out carriage roads. East and West Fens, comprising 29,348 acres, were similarly divided.

In these two acts one thing stands out. It is that enclosure was on a parochial and not an individual basis. It was soon realised that this was insufficient, that for cultivation the land required individual ownership. Consequently amending acts were passed in 1802(1) and in 1810(2). These provided for allotting in severalty and enclosing, and the awards were made in 1820. It may be thought that this discussion of enclosure is of greater interest to the economic historian than to the historical geographer. This is not so. For the geographer is primarily concerned with the landscape, and the landscape of these fens shows variously large fields and small fields, large farmhouses and small cottages. In fact the arable farming and the settlement which followed drainage, developed on varied lines as a result of variety in enclosure.

Forty-eight parishes had rights of common. What happened when each householder was awarded his claim to land? Obviously there was the geographical fact of distance to consider. Reasonably enough parishes were, as far as possible, allotted lands in the neighbouring fen. But few if any fen lands were near enough to be conveniently cultivated by people living in the village. Thus migration into the fen was essential. Faced with the problem of whether to go or stay, the forty-eight villages must have been in something of a ferment, and what each householder decided we shall never know. But material which throws some light on the migration into the fens is available. It can be found in the unpublished returns of the 1851 census(3). The birthplace of each person is recorded and although 1851 may be 30 or 40 years after the first settlers arrived, it is clear that most of the householders were, in fact, first generation immigrants. Out of a total of 755(4) householders, only 49, or 6% were born within the fen. Thus 94% came from outside.

Figure 5 shows where most of the fen householders were born. 45% were born in places with fen allotments and 40% elsewhere in Lincolnshire. Thus the settlement of the fens resulted essentially from a migration within the county, only 15% coming from other parts of England. It is worth noting that most of the latter came from the neighbouring counties of Norfolk, Notts., and Cambridgeshire. A more detailed scrutiny shows that from the places with fen allotments, there was a very unequal migration. Sibsey, Coningsby, Stickney, and Leake

(1) 42 Geo. III, Cap. 108.

(2) 50 Geo. III, Cap. 129.

(3) Public Record Office, *Home Office Records*, 107 (2098, 2108, 2109).

(4) This figure represents the bulk of the fen householders but is not complete owing to lack of clarity in a small number of parish records.

supplied 44%, and as much as 20% of the whole immigration. As regards the rest of the county, it is clear that the majority came from the higher silt lands and the Wolds. In summary therefore one can say that most of the fen people came from its borderlands, and that although some of the immigrants took up lands granted to them in place of common rights, most of them were outsiders with no previous use of the fen. It follows therefore that many commoners sold their allotments rather than migrate to them.

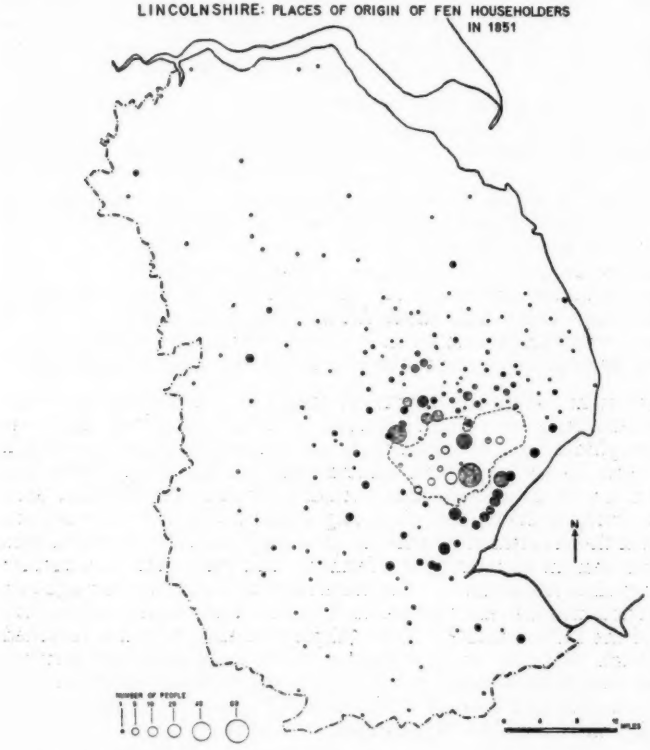

Fig. 5

Dashed line marks approximate boundary of fen ; open circles represent fen settlements ; stippled circles represent settlements with rights of common in 1801, and black circles mark other settlements.

So far the discussion on immigration has depended on the 1851 census. But some statistics are also available in the published returns of earlier years and it is essential to make what use one can of them. For the geographer, however, there are some serious drawbacks. It will be remembered that the fen was first divided amongst the interested parishes, and subsequently amongst individuals. But although individual ownership replaced parish ownership, the area concerned still remained, for a time at least, the fen allotment of the parish as regards both ecclesiastical and civil administration. Thus the fen population was at

first included in the parish total, and although by 1811 some considerable settlement of the fens had taken place, there is no statistical material to show it.

That it had taken place is demonstrated by the passing of an act in 1812 bringing about the formation of seven townships from certain extra parochial lands in the three fens(1). According to the preamble, nearly 14,000 acres had already been sold and the population was rapidly increasing. This entailed problems in administration, for the ancient parishes were unwilling to take on the obligation of supporting the poor in the rapidly developing fen allotments. The act therefore made the new townships responsible for poor law administration.

In East Fen two townships were created, viz. Eastville and Midville, the rest of the fen remaining as parochial allotments. Five townships were carved out of West and Wildmore Fens, and named Frithville, Carrington, Westville, Thornton-le-Fen, and Langriville. Here also some parishes retained fen allotments. Thus the census of 1821 does not provide complete statistics for the fens. It does, however, give the total of the seven townships.

TABLE 1

West and Wildmore Fens		East Fen	
Township	*Population* 1821	*Township*	*Population* 1821
Frithville ..	272	Midville	139
Langriville ..	195	Eastville	118
Thornton-le-Fen ..	141		
Carrington ..	139		
Westville ..	102		
Total ..	849	Total ..	257

Table 1 suggests that the influx into the west had been much greater than into the east. This may partly account for a small difference in employment. All the 41 familes in East Fen were engaged in agriculture, while in the west 11 were engaged in trade or manufacture so that 9% of the population was non-agricultural.

It is fortunate for geographical purposes that the 1st edition of the 1" O.S. map of the area was published soon after the census, in 1824. From this much can be learned about the new fen settlement. In general it offered a marked contrast to the settlement pattern on the Wolds and higher silt lands where, it will be remembered, grouped settlement predominated. In the fens most of the houses were either dispersed or very loosely grouped. Another obvious but important feature is that most houses were built along the roads and drains. Evidently the chief

(1) 52 Geo. III, Cap. 144.

siting factor was convenience of access(1). This resulted in a strongly linear pattern of settlement with a few exceptions where farm houses had been built out in the fields. Further it can be seen that most of the houses were strung out loosely in a north-south direction since the chief roads and drains were so aligned. Thus there were more houses along Hobhole Drain than its tributaries. The final point is an exception. There were a few places where grouped settlement was developing. In the west New Bolingbroke and Frithville might rank as villages and New York and Thornton-le-Fen as hamlets. In the east there was a hamlet of Eastville.

New Bolingbroke is of special interest. It was a speculative venture by John Parkinson, the lessee of crownlands in the parish of Bolingbroke. In 1816 he built a number of houses on the fen allotment, "In such a situation that it (the settlement) might have a water communication with Boston and nearly all parts of the surrounding fens, by means of the navigable drains"(2). In 1821 Bolingbroke's market was transferred to it. Parkinson's enterprise ranged still further for he built a factory "For the weaving of crapes and bombasins, similar to those of Norwich"(3). "But", continues Allen, "It did not realise the expectations that had been formed". Another writer more bluntly pronounced it "A severe failure"(4). The market did not flourish either. Allen's comment reads, "The market is not likely to rise to much importance, in consequence of the flourishing state of the markets at Boston, Spilsby and Horncastle, all within a distance of 9 miles"(5).

Agriculture and Settlement in the later 19th century.

The year 1851, halfway through the century, is the next convenient point for examining the changing geography of the fenland. Two reports provide authoritative information on drainage and farming(6). According to them the drainage of the western basin was generally successful, gravity draining being sufficient without the aid of pumps. East Fen also depended on gravity drainage, but the general comment, "The fen being pretty well drained", suggests that there was still something to be desired. Within the next years this became more apparent. Like the Bedford Level East Fen was experiencing peat shrinkage and because of the lowering of the surface level, the drainage gradient was reduced. In the wet winter of 1866 a large part was flooded for many weeks. In 1867 therefore a further drainage act authorised the construction of Lade Bank Pumping Station on Hobhole Drain, and at the same time provided that the drainage from the western basin should pass to Hobhole Sluice. Much improvement resulted and still further benefit was gained when the Witham outfall was improved after 1880.

(1) White's *Directory of Lincs.*, in 1826 gives information on the sailing packets which plied between Boston and the fens on Wednesdays and Saturdays. There were services (*a*) To Wildmore and West Fen, including Bunker's Hill and New York, New Bolingrooke and Revesby. (*b*) To East Fen. (*c*) To Sibsey, Stickney and Stickford.

(2) White, Wm., *Gazetteer and Directory of Lincs.*, 1842, p. 273.

(3) Allen, Thomas, *History of County of Lincoln*, 1830, Vol. 2, p. 105.

(4) Noble, Joseph, *Gazetteer of Lincs.*, 1833, p. 49.

(5) Ibid., p. 273.

(6) Clarke, J. A., "On the Great Level of the Fens," *Journal of Royal Agric. Soc.*, Vol. VIII, 1847, pp. 80-133 and "On the Farming of Lincs.", *Journal of Royal Agric. Soc.*, Vol. XII, 1852, pp. 259-414.

Drainage and cultivation had emphasised another contrast between the east and west fen basins, viz. their differences in soil. Basically the peats of East Fen were more fertile than the silts and sands of the west. The peats had been further improved by claying, i.e. the underlying clays had been mixed with the unconsolidated peat to give a firmer texture to the soil. With these facts in mind it is reasonable to enquire whether agriculture reflected the soil differences. In the reports there is little evidence of this. Both areas were almost entirely arable, growing cereals, roots, clover, ryegrass and coleseed, and maintaining their sheep on fodder crops. Both areas were said to be well farmed.

The next questions to consider concern population. Had there been much increase after the initial immigration? And if so, had the greater fertility of East Fen attracted more people, thus counterbalancing the initial influx into the western basin? The published returns of the 1851 census are more satisfactory than those of 1821 because 21 fen allotments are separately recorded. But there are omissions, notably for East Fen. Table 2 therefore includes both published and unpublished statistics and shows the bulk of the fen population.

TABLE 2

West and Wildmore Fen		East Fen	
Townships	*Population* 1851	*Townships*	*Population* 1851
Frithville ..	367	Eastville	228
Langriville ..	292	Midville	142
Thornton-le-Fen ..	200		
Carrington ..	167		
Westville	137		
Fen Allotments ..	1,883	Fen Allotments ..	689
Total ..	3,046	Total ..	1,059
Area in acres ..	27,585	Area in acres ..	12,424

Clearly there had been a considerable rise in population. It is equally clear that in spite of the greater fertility of East Fen, the western fens supported three times as many people although their area was little over twice that of East Fen. In the west there were 8 acres per head of population, in the east 12. The unpublished returns provide material which bears on this question of varying population. Each person's occupation was recorded and for most farmers the size of holding was stated. The first thing one notes is that farms varied greatly in size. The largest was 1,180 acres, a number ranged between 100 and 400 acres, and at the other end of the scale there were many smallholdings of 3-20 acres.

Thus the question arises as to whether there is a correlation between the size of holdings and the size of population. Did, in fact, the leasing of smallholdings attract a big influx into some parts of the fen, leaving other parts, where bigger farms had been established, comparatively empty? Table 3 gives representative material both from townships and fen allotments.

TABLE 3.—FARMS AND POPULATIONS IN 1851

Township or Fen Allotment	*No. of Farms*	*Total Area of Farms*	*Average Size of Farms*	*Total Population*	*No. of Farm Acres per Head of Population*
Eastville ..	11	2,579	234	228	11
Carrington ..	8	2,094	262	167	12
Frithville ..	15	1,139	75	367	3
Boston ..	2	460	230	21	22
Benington ..	6	106	18	98	1

These representative examples appear to show conclusively that the densest populations were to be found in areas of smallholdings such as Benington. Here the largest farm was 39 acres in size, the smallest 3. Besides the 6 farmers there were also 2 cottagers, and 11 householders who were agricultural labourers and probably owned small plots of land. Thus the average size of holding was doubtless below the 18 acres recorded in the table. In contrast Boston's allotment had been divided into 2 farms only. These were managed by bailiffs who lived in 2 houses, providing lodging also for 6 agricultural labourers, so that the total population of 21 was supported by 460 acres of farmland.

This fact of contrasted farm sizes appears to be the basic reason for the greater density of population in the western fens. Generally speaking there were far more smallholdings in the west than in the east where large farms were more characteristic. There is also the contributory factor that there were more traders and craftsmen in the west.

The developments of the later 19th century can only be considered briefly. Since the fenland was mainly devoted to arable farming, the agricultural crises of those years were of great importance. Parish returns for agriculture were available after 1866, but unfortunately the boundary changes that took place in the fens between 1880 and 1900 make it impossible to assess absolute increases or decreases. Percentage comparisons offer some information however. In 1870 only 23% of the townships of East Fen was under grass as against 28% in the west. Cereals were outstandingly important in both areas, wheat predominating. By 1901 there were significant changes. In the east, grassland had declined to 17%, and had risen to 31% in the west. Arable farming showed a change in emphasis. The western fens grew more potatoes and less cereals while the east had increased percentages of both. Thus the greater fertility of East Fen appears to have enabled it to survive the crises more successfully than the west, and this in spite of the fact that holdings had dropped from an average size of 116 acres in 1870 to 82 acres in 1901.

What, in the meantime, had been the changes in population? Boundary changes make it impossible to graph the parish statistics, since 3 new parishes (Wildmore, West Fen and New Leake) were created in 1880 and 1894, and big changes in others were made. But a general decline is evident. In 1901 East Fen had a population of 927 and the western fens 2,588. There was a density of 1 person to 10 acres in the former and 1 to 8 in the latter. This suggests that there was less difference than formerly between the two and correlates with the agricultural changes.

So end the developments of a century and the successful drainage, cultivation, and settlement of a long neglected area.

Bibliography.

The two chief works on the drainage of this area are W. H. Wheeler, *The Fens of South Lincs.*, 2nd ed., 1896, and H. C. Darby, *The Draining of the Fens*, 2nd. ed., 1956.

I wish to thank G. E. Buchner, Esq., A.M.I.C.E., Engineer to the Witham Fourth District Internal Drainage Board, for his help in providing material.

THE AGRICULTURAL GEOGRAPHY OF DERBYSHIRE IN THE EARLY 19th CENTURY

H. C. K. Henderson

The agricultural geography of Derbyshire in the third decade of this century was analysed in the Land Utilisation Memoir of the county published in 1941, and in that volume the historical aspects of the period back to Tithe times were summarised for Central Derbyshire. It was shown that the agricultural distributions at all dates back to 1840 bore a close affinity to the solid geology, and that four main zones were discernible (Fig. 1) :

(i) The Carboniferous Limestone Plateau, mostly at an elevation of a thousand feet or more, where animal farming had been the order and where the production of milk had been the prime concern of the farmer. Cheese making was prevalent and remained so till the demands for fluid milk in the London area led to the establishment of a milk depot at Rowsley by the Express Dairy Company.

(ii) The Millstone Grits, which at no date carried much arable land, owing to inferiority of soils and exposure of position, had been characterised by sheep farming and grouse shooting on poor pasture. The narrow shale shelves bear mixed soils and improved land was usual on these.

(iii) The Coal Measures offered an area of mixed farming with a fair proportion of arable land at all dates especially in relation with the sandstone elements, e.g. the Wingfield Flags. The Middle Measures showed a consistently higher proportion than the Lower Measures.

(iv) The Magnesian Limestone, which carries the finest large stretch of arable land in the county, was shown to be basically a sheep and barley terrain.

Southern Derbyshire, with its Triassic soils, was not considered historically in this report, but it was known to writers of the period as the granary of the county, and produced cereals well in excess of local demands.

It is the object of the present article to take our knowledge further back in time to the early part of the 19th century, and for that purpose I have turned to the Crop Returns of 1801, which have been studied in recent years for a number of counties by several workers—one should recall that these returns were made at the request of Lord Pelham through the medium of the clergy, and that in many districts, the farming fraternity eyed the request with suspicion, fearing either an enquiry as to its honesty in payment of tithe, or the threat of some new form of taxation. All too frequently there are 'nil' returns. None the less, sufficient can be mapped to present an outline of the position in 1801. (Fig. 2).

Fig. 1

The *Limestone Plateau* is exemplified by a group of returns north of Ashbourne, in which oats is the prevalent cereal, and though small quantities of wheat were grown, barley is absent. The return for Bradbourne has the following remarks :—"a considerable quantity of cheese—young stock are reared—in general good grassland—oatcake is the common bread." The remarks on Tissington are succinct—"dairy and sheep". Fenny Bentley is recorded as having about 30 inhabited houses, some dairy farms with 20 or 30 cows and no surplus corn. The Kirk Ireton document records Callow Moor as an individual common of 400-500 acres between Kirk Ireton and Callow—this was enclosed under an Act of 1805. It should be noted that Bakewell includes five townships—Baslow, Bubnell, Calver, Curbar and Froggat, most of which are at least partly on the Millstone Grit and therefore have the effect of giving a higher return for wheat than would be the case for Bakewell proper. The only crop, other than those mapped, with an appreciable return is turnips, of which there were 15 acres in Kirk Ireton, 25 acres in Parwich and 177 in Hartington.

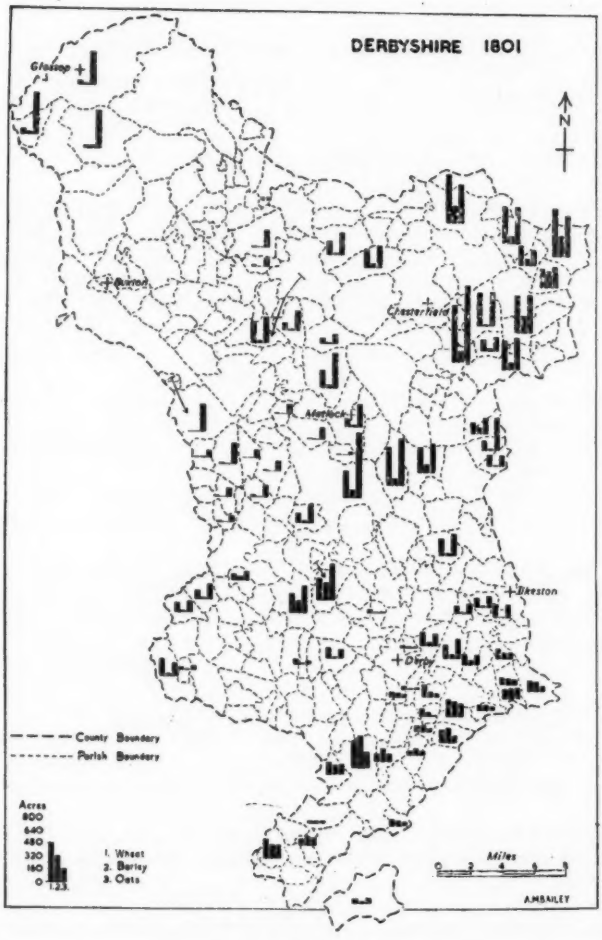

Fig. 2

The area covered by the individual columns is true to the scale of the base map.

The *Millstone Grit* country has relatively few returns, but those available show remarkable similarity in that the wheat acreage is about half that of oats, and there is an appreciable figure for barley. There is little doubt that the Wirksworth returns are affected both by size of parish and by the inclusion of Carboniferous Limestone country, but the nature of the cereal curve is typical of the Millstone Grit. The parish also had 116 acres of turnips, a crop very little represented elsewhere on the Grit. Edensor returned 19 acres of turnips and was the sole Grit parish to grow rye (7 acres). Cromford is largely on Millstone Grit but has a return more typical of its Limestone portion; the following remarks were entered on the document :—"1270 acres of land of which a

considerable quantity is moorland—a very little is tilled, many cows being kept here for the accommodation of the people employed in spinning cotton"—this is presumably a reference to the several mills whose sites still exist in the Via Gellia valley, and includes the Arkwright or Masson Mill in the Derwent Gorge.

On the *Coal Measure* soils, wheat acreages are of the same order as those of oats, and some parishes returned appreciable figures for barley. There were only two returns for turnips worthy of mention,—North Wingfield had 97 acres and Eckington 210 acres, while the latter was the only Coal Measure parish to record a worth-while acreage of peas and beans (120 acres). In general, it is seen that Middle Coal Measure soils, as at the later dates, were more fully cultivated than their Lower Coal Measure counterparts. The 1801 documents make no mention of a notable local specialisation in the area around Clay Cross ; about 1740, camomile was introduced into this area, and by the end of the century it was grown in four parishes (Kelstedge, Milltown, Overton, Stubbinedge) on the Limestone shales of the Ashover Dome and in nine parishes (Alton, Brackenfield, Clay Cross, Hanley, North Wingfield, Shirland, Stretton, Woodthorpe and Wooley Moor) on Coal Measure soils. The total acreage is quoted by Farey as being "about 200" and the crop, he says, was sold to London Druggists for use as camomile tea which was prescribed for stomachic disorders. Today camomile is imported from Belgium but in the Tithe records, reference was made to 4·5 acres in the parish of Pilsley (earlier a township in North Wingfield).

The *Magnesian Limestone* area is confined to some half-dozen parishes in the north-east, and of these, only Whitwell and Elmton have returns, though Scarcliffe, and to a less extent, Ault Hucknall show evidence that they transgress to the Magnesian Limestone. In each case wheat was as important as oats, and barley was a prominent crop, while all four had considerable acreages of turnips, thus emphasising the importance of sheep in this zone. Although Farey lists a large number of parishes with no 'green' crops in their rotations, none of these is on the Magnesian Limestone. The return for Whitwell bears the following somewhat contradictory remark :—"Bad limestone land but an excellent crop of all sorts of grain well got in".

In the *Triassic Lowlands* of the Trent Valley the soil is developed largely on Keuper Marls though Bunter Beds fringe the southern end of the Pennines near Ashbourne and provide relatively warm soils which result in a fairly high proportion of arable land on which both wheat and barley had considerable acreages. In the extreme west the superficial drift led to heavy soils and a clay land type of husbandry with barley unimportant. The south-eastern portion of the area has all three cereals with oats usually the least important. The parish of Swarkestone which lies alongside the Trent is recorded as consisting of "about 950 acres, equally calculated for grazing and plough except the Trent meadows which are liable to flooding which is about 25% so that of the rest about one third is tilled—No rape but cow cabbage instead and increasingly popular". The nearby parish of Foremark has 79 acres of rape (including cabbage) recorded.

Enclosure of the common fields of Alvaston and Boulton was effected by an Act of 1802 and the Award is dated 1805. This followed closely upon the comment in the 1801 records—"parishes very intermixed—enclosure would lead to improvement of much waste land".

The common fields were stated to total about 2,000 acres but to be of unequal size. Their use in 1801 is recorded as :

1. Wheat and Barley.
2. Oats and Peas and Beans.
3. Fallow.

As an inlier in the south-eastern part of the county, there is an area of Millstone Grit surrounded by Keuper Sandstone, and though the crop returns make no reference to the parish of Melbourne, Farey states that Lord Melbourne's estate provided allotments following early enclosure while the rest of the parish was affected by the Enclosure Act of 1791. This parish was one listed by Farey as an area of market gardening and its modern importance has therefore originated from the late Eighteenth Century. At a later date, Melbourne specialised in the raising of quick set hedges for the developing railways but it reverted to market gardening and its industry is still spreading.

Writers of the period such as Pilkington and Farey record no complaints of suffering resulting from the enclosures and claim that the general outcome in Derbyshire was of benefit to all. Farey associates the change-over from sheep farming to dairying with the enclosure of the Limestone and Gritstone Moors though enclosure came relatively late to the Grit Moors as is evidenced by the large size and regular shape of the individual allotments. Farey lists 36 parishes with open commons of which about 25% are recorded as small, while he also records 13 parishes as still having open arable fields. Of these 13, 9 are on the Red Marls, 3 on the Coal Measures and, on the Magnesian Limestone, Whitwell which was enclosed under an Act of 1813 ; the award is dated 1823 and the area then enclosed totalled 950 acres. As a general indication of geographical progress of enclosure, most parishes south and east of a line from Ashbourne to Chesterfield had been enclosed by Act by 1800, but, except for a group of five townships to the west of Bakewell, parishes to the north and west were enclosed after the Crop Returns and indeed between 1810 and 1865 (Cresswell near Hope Act—Award is dated 1872).

The absence of crops other than cereals, potatoes, peas, beans and turnips in the 1801 returns is to be regretted, especially in a livestock farming area where one might well expect rotation grasses to be in evidence ; but of the rotations recorded by Farey, 24 have two or more corn crops in succession. Seven have no green crop at all and consist of a four course rotation with cereals and fallow, and only 9 have no successive cereal crops in the rotation. This suggests rather that farmers of that date, like the modern successors in Derbyshire, were aware of the value of regular liming of their pastures which are still farmed on a very long ley system in the Carboniferous Limestone area.

Taken as a whole, these features of the early Nineteenth Century can be said to have set the stage of the modern aspects of the agricultural geography of Derbyshire, with the exception of the change in the use of the milk from cheese to fluid, a change which took place only 25 years or so ago, and the more modern overall improvement of yields.

REFERENCES.
(1) "1801 Crop Returns"—*Public Record Office—HO* 67/14 Lichfield.
(2) John Farey, *General View of the Agriculture of Derbyshire*, Vol. II, 1813.
(3) J. Pilkington, *A View of the Present State of Derbyshire*, 1789.

INDUSTRY IN THE SMALL COUNTRY TOWNS OF LINCOLNSHIRE, NORTHAMPTONSHIRE AND RUTLAND

IAN G. WEEKLEY

The problems of industrial development in small country towns have received little attention in the past and indeed until recently their national significance in industry has been insufficient to warrant their detailed consideration. During and especially since the war, however, these towns have made an increasing though modest contribution to industrial expansion in Britain. Their recent industrial growth can be ascribed first to conditions of full employment since the war in the major urban areas and secondly to the policy of planned control of the growth of many large towns. Some of the recent industrial expansion in country towns is therefore the result of normal economic forces, the dominant one being the demand for labour ; some is the result of planning to restrict further growth of urban sprawl around the large towns. The industrial expansion in the small country towns may also help to check the decline in prosperity that some of them began to experience in the inter-war period when rapid improvements in road transport drew off some of their trade to the larger towns.

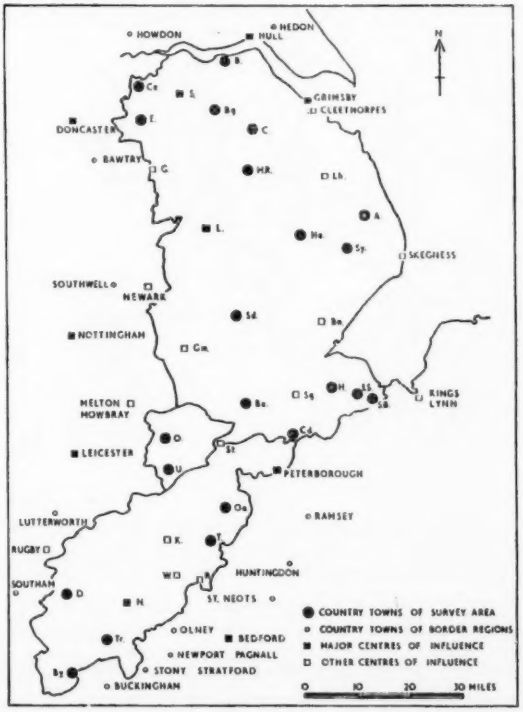

Fig. 1
Country towns and centres of influence.

Consideration of the problems of industrial development in small country towns is restricted in this article to those in the eastern, mainly agricultural part of the East Midlands, comprising the counties of Lincoln, Northampton and Rutland. The criteria adopted for defining a small country town are as follows :

(1) the settlement must have some degree of town status(1) ;

(2) it must for the most part be and have been concerned in supplying sales and services for an agricultural hinterland ;

(3) it must have had a population in 1951 of less than 8,000 but more than about 2,000.

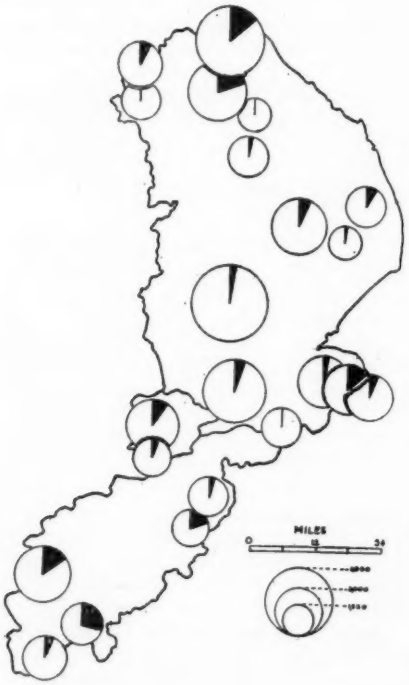

Fig. 2

Country towns : comparative industrial development, 1954.

The total population of each town is shown by a circle and the black segment represents the proportion employed in industrial plants within the town.

(1) A. E. Smailes, "Urban hierarchy of England and Wales", *Geography*, 1944, pp. 41-51.

Criteria (1) and (2) serve to define a country town and require no further explanation. The third criterion, which relates to size, is adopted because in the area under consideration there are no towns between 8,000 and 10,000 in population and those over 10,000 had already before the war acquired industries of more than local significance. They had to some extent, therefore, ceased to be essentially country towns in that they depended for their prosperity on more than being simply market towns for a small rural area. It appears likely that these larger towns may continue to grow and attract industry of their own accord without experiencing most of the problems appertaining to the smaller towns. The lower limit of 2,000 is less easily justified and five towns, all heads of Rural Districts but with less than 2,000 people, are included for examination.

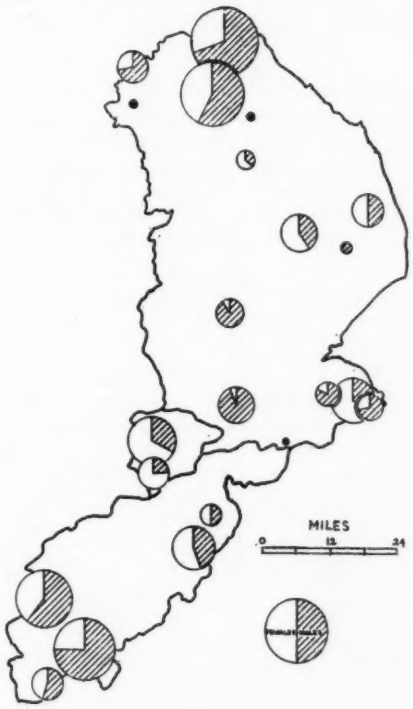

Fig. 3

Country towns : employment in manufacturing industry, 1939.
The circles are proportional to the number of persons employed in industry in each town.

The 22 country towns selected on these criteria are shown in Figure 1 in relation to the larger country and county towns in the region. The even distribution is broken in only two areas, in Lincolnshire where centralisation of trade on Lincoln is considerable and where no really competitive centre exists for some distance around the town, and in

mid-Northants., where an industrial concentration of eleven small centres without important rural affiliations has grown up and which includes the expanded market towns of Kettering and Wellingborough(1). The settlements in this concentration clearly do not fit the criteria established above and are not therefore shown on Figure 1.

The general level of industry is not high even today (Fig. 2), and indeed there are no firms at all in Caister, Crowland and Epworth. Where industry does exist the percentage of the population employed in industry within each town ranges from 1·6 in Spilsby, 1·8 in Sleaford, and 2·8 in Holbeach to 15 in Daventry, 18 in Brigg, 19 in Thrapston, and as high as 29% in Towcester. As these figures indicate there is some regional differentiation in the level of development. Industry is found chiefly in North Lindsey, and in Rutland and Northants., especially in south Northants. With the exception of Long Sutton the small towns of southern and central Lincolnshire have a notably lower level of development.

The Development of Industry up to 1939.

Figure 3 shows the pattern of industrial employment subdivided between the sexes in the country towns in 1939. The general level of industry was low and the plants, except at Daventry and Thrapston, chiefly employed male workers. These two towns in the south, and the three towns in North Lincolnshire were more heavily industrialised than the remaining small country towns in the area.

TABLE 1.
DATE OF ESTABLISHMENT OF INDUSTRY IN COUNTRY TOWNS.

Grade (Standard Industrial Classification)	*Production.*	*Before* 1914	1914-1939	*After* 1939
3	Non-Metalliferous Mining ..	6	2	2
4	Chemicals, etc.	1	1	1
5	Metal Manufacture	–	–	–
6	Engineering, etc. (excluding Agricultural Engineering) ..	3	2	6
	Agricultural Engineering ..	3	3	2
7	Vehicles	1	1	1
8	Other Metal Goods	–	–	1
9	Precision Instruments ..	–	1	–
10	Textiles and Hosiery ..	1	–	1
11	Leather	1	1	–
12	Clothing	1	4	7
13	Food and Drink	8	5	2
14	Wood	1	4	–
15	Printing	2	–	1
16	Toys and Plastics	–	–	3

(1) It is noteworthy that these eleven small industrial settlements are perhaps unique in British urban geography. While it is true that their form as a group is common to many British coalfields and to valleys where water power was used in the early stages of the industrial era, in Northamptonshire there are no such obvious reasons for their existence. Nor are they outer surburban growths of any major town.

The type of industry which had developed by this date was of a special character. In most cases its presence was associated with supplies of local raw materials (usually drawn from agriculture) or with the production of goods for the local agricultural and domestic market. As Table 1 shows, thirteen plants concerned with food and drink were set up by 1939, eight with bricks and tiles (Grade 3), six with agricultural engineering, and a further five with wood products. It is worth noting too that all the five (non-agricultural) engineering firms in existence had developed from small beginnings supplying a small local market and only subsequently expanded to supply a larger non-local market.

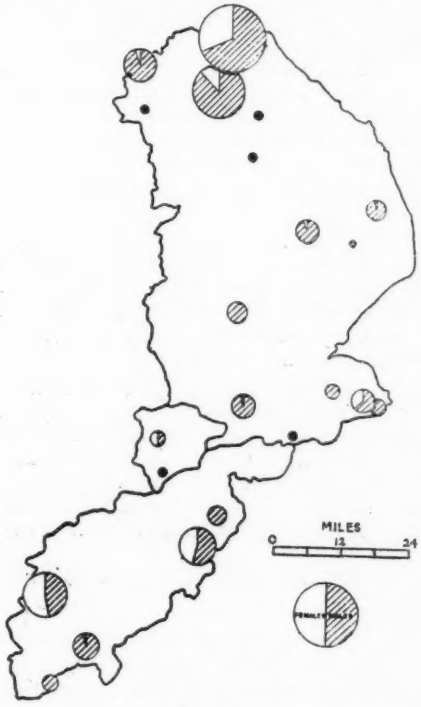

Fig. 4

Country towns : employment in manufacturing industry, 1954.
The circles are proportional to the number of persons employed in industry in each town.

The Development of Industry since 1939.

Figure 4 shows the distribution of industrial employment in 1954. Certain important changes had taken place since 1939.

(1) There had been a considerable expansion in the towns of the southern counties, based chiefly on female labour.

(2) There had been a slight further growth in mid-Lincs., also using female labour.

(3) In north Lincs. little expansion had taken place, except for the establishment of a clothing works at Brigg, while in Kesteven and Holland the only developments had been a slight further expansion of old established firms.

That the type of industry has changed as well is obvious from Table 1. Of the 27 new firms which have been set up since 1939 seven are clothing works, six engineering (chiefly light engineering), and three plastics. At least two-thirds may be described as light industries.

The New Industrial Mobility

Mobility of industrial resources is essential to successful industrial operations. Railways, though reasonably efficient as far as industry is concerned, tended during the nineteenth and early twentieth centuries to concentrate industry within the comparatively limited area which they served. The development of road transport, however, mobilised industry by allowing door to door communication within the widespread limits of the road network. Similarly, since the early 1930's particularly, widespread production and use of electricity as a form of power has reduced the locational significance of the coalfields and of accessibility to fuel supply.

This new mobility has had two chief effects in the country towns. More distant firms can now compete in the local rural market which was previously fundamental to country town industry. But it also means that firms in country towns are now in a much better position to compete in the national market provided they suffer no technical or managerial disadvantage by virtue of their location.

Whereas before the war therefore most firms had been set up in country towns to use local raw materials or to supply the local market these are now less important. Even the older firms, such as breweries, have been forced to expand their service areas or to amalgamate in order effectively to withstand competition. The new developments are of an entirely different character, and are based on locational advantages which, if more subtle, are no less significant in the national economy.

The Present Factors in Location

(1) *Labour Supply.*

In neither the country towns nor the local rural area is the population very large, so that the labour potential cannot be very great. In fact if unemployment statistics are taken as the guide there is no surplus at all. This is because the reserve is not among the insured workers but is "hidden". In other words it is composed mainly of female and juvenile labour, especially married women and girls at home. To some extent there is also available a seasonal surplus from agriculture but few manufacturing industries are able to take advantage of this. Furthermore this labour is scattered over a wide area of country since it is composed chiefly of agricultural dependants for whom the country town acts as the labour market.

There is too a considerable number of men who travel daily from the country towns to work in the major centres. For example 8-10 buses leave Bourne daily taking workers to Stamford and Peterborough. In certain cases this may be considered as an additional reserve for prospective firms in the country towns themselves.

Since the labour supply is chiefly female it is obvious that certain limitations will be imposed on firms that come to the country towns with the intention of using this labour.

(*a*) The industry must be light in character.

(*b*) The industry should be adaptable to considerable changes of personnel because many of the employees will be young women of marriageable age.

(*c*) The industry should allow of repetitive work or other work of a kind that does not need long periods of training.

(*d*) The industry should be capable of using labour for comparatively short and/or irregular periods, so that some shiftwork system may allow the employment of housewives and others with alternative duties.

(*e*) The industry should be sited centrally to its source of labour (that is in the country town) and have efficient means of transporting its workers from the surrounding rural area.

(*f*) The industry should be capable of efficient small scale organisation because the labour supply is itself limited.

Before the war few firms, except for four clothing plants in south Northants., found that considerations of labour influenced in any way their choice of location. Since the war however locational factors have become so complex that firms can rarely account wholly for their location by reference to any one factor. It is notable however that 80% of the post-war firms in the area considered labour to be the basic locational influence. In Northamptonshire and Rutland alone this factor was of great interest to all the firms established, and the Board of Trade claimed that labour and premises were the chief considerations to 98% of the firms seeking rural sites in the North Midland region. Though the available labour is composed in part of agricultural dependants, agriculture is not only a supplier of parasitic labour, but also an alternative user of labour in competition with industry. This competition arises chiefly over the light labour required seasonally. Consequently in areas of intensive agricultural development such as the Fenland, the development of industry unrelated to agriculture may be neither successful nor desirable except as a means of diversifying the economy.

In Figures 3 and 4 the changes in the industrial pattern and in the composition of labour have been indicated. It is apparent that there has been a considerable recent increase in the use of female labour. This trend is emphasized in Figure 5. The diagram shows that since 1939 (excluding the exceptional war years where the rise indicates as much the mobilisation of the men as the fresh employment of the women) there has been a steady increase in the number of females employed. At the present day the figure in the country towns is much nearer the national average than it was in 1939, due to a considerable expansion of light industries.

The full utilisation of the labour pool is obviously dependent upon accessibility, so that the problem of rural transportation becomes a very important one. With adequate transport the potentialities of the surrounding rural area are greater than might be supposed. For instance

it was estimated at Oakham that one incoming firm would obtain a maximum labour force of 60. Now by using the hidden reserve, and by sending buses into the rural area this firm employs over 250 persons.

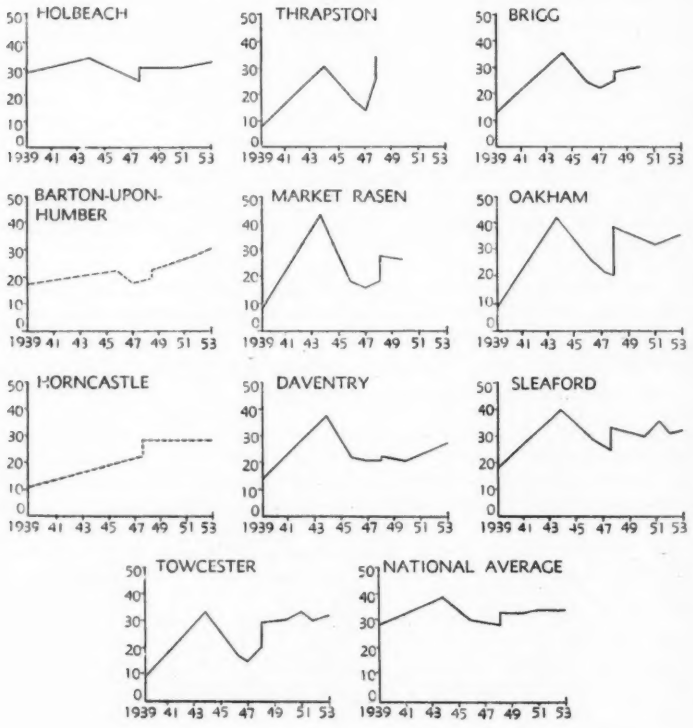

Fig. 5

Insured females as a percentage of total insured for certain Labour Exchange areas and the national average.

Data were plotted for 1939, 1944, 1946 and every year thereafter to 1953 except where a dashed line indicates the lack of information for 1939 and 1944. The two plots for 1948 on each graph result from a change in the method of computation in that year.

Yet the very character of the labour presents certain problems in these areas, chief of which is the difficulty of obtaining a supply of skilled workers. Three solutions are normally adopted :

(1) to bring in key workers from other areas ;

(2) to attempt to attract the local skilled labour away from work in the larger centres ;

(3) to introduce training schemes.

Yet though each of these methods is valuable, it is obvious that some system of training must supersede the first two once the firm has settled down and become absorbed into the labour structure of the town.

It appears then that available labour is a primary requirement of firms moving to, or setting up in, country towns. Its presence has provided the major attractive feature since the war and has directed the general location and character of the new industry. But it has not been entirely responsible for the local variations in development throughout the region.

(2) *Premises.*

To nearly all the industrialists the availability of old buildings suitable for conversion was also of great importance. Since 1939 old buildings have been used considerably by incoming firms. For example, development in the central Lincolnshire towns has been mainly by firms set up in old buildings and there has been extremely high development in the south of the survey area by new firms, two-thirds of which have been established in old buildings.

It is notable that of all the firms in the three counties those in new premises have an average employment of 169·6, while the average of those in old buildings is only 50.6. As these figures suggest old premises are usually small and are therefore suitable only for small plants. It is however the small firms, both unable and unwilling to lock up too much capital in new ventures, who value them most. The rental of old buildings is reasonably cheap, and allows of comparatively easy entry into the country town when times are good and escape when times are bad.

The Influence of the Major Centres

Of the major industrial centres, Leicester, Northampton and London have contributed most to the industrial expansion of the small country towns in Lincolnshire, Rutland and Northamptonshire since the war. Apart from large new engineering plants established mainly in south Northants. where conditions suggest greater stability and warrant therefore more permanent investment, much of the expansion has been by light clothing firms. This is in keeping with the industrial structure of Leicester and Northampton and, of course, London. Nottingham, whose economy might seem appropriate to the dispersal of industry into the rural area, has not participated because it is near a mining district where female labour has been available for local industrial expansion. Until this labour is fully employed it is unlikely that Nottingham firms will develop branches in even the more accessible of the Lincolnshire towns. Doncaster and Sheffield are in a similar position with regard to coalfield labour supplies and are mainly engaged in the heavier, male-employing industries. Likewise many of the bigger towns within the survey area, notably Peterborough, Grantham, Lincoln, Gainsborough and Stamford, are largely concerned with heavier types of engineering which is unsuitable for dispersal to the small country towns unless immigration of male workers and considerable expansion of population are envisaged. This, the planned expansion of small towns, is however another problem outside the scope of this article(1).

(1) See "The Expansion of Daventry", *East Midland Geographer*, No. 4, December, 1955, pp. 52-53.

Conclusion

There has been a steady development of industry in the country towns of Lincolnshire, Northamptonshire and Rutland since 1939. The greatest expansion has taken place in the south—chiefly in Towcester, Daventry, Thrapston and Oakham ; and to a less extent in Brackley, Uppingham and the towns of central Lindsey. In the rich agricultural areas of south Lincolnshire there has been little recent growth. Barton and Brigg both have considerable industry but the bulk of their firms were set up before the war.

Industrial growth since 1939 differs from earlier development in that it is generally not tied to the local market nor to local supplies of raw materials. Its presence is connected with the proximity of the country towns to larger centres in which there is an unsatisfied demand for labour and space. To some extent both labour and space are available in the country towns. Thus the recent development is not due to changes in the country towns but to changes in the condition of the national economy. The small pools of labour were available before the war as much as they are today. It is only the coming of full employment that has given them the locational significance they now enjoy for manufacturing industry.

The character of industry in the major centres means that only those of the south—chiefly Leicester, Northampton, London and the towns of mid-Northants.—can or need as yet set up branches in the country towns. The high level of development in Northants. and Rutland is due to their position central to these large towns and across the main population axis, since the efficiency of any branch factory will increase with its nearness to the main works.

Within the general locational margin set by these factors, detailed considerations of premises and of local attitude have played an important part in determining the differential development. In certain areas the character of agriculture and of the social structure have acted against the new expansion. It should be remembered however that agriculture must remain the primary concern in rural areas and the safeguarding of agriculture from unwise industrial competition must remain important. The value of industry lies in its ability to stabilise the employment structure of the country town and to allow the latter to play a full part in the national economy.

THE DIFFERENTIATION OF THE GLACIAL DRIFTS OF THE EAST MIDLANDS

K. M. CLAYTON

Recent research on the Pleistocene Period has led to some advance in the problem of establishing a chronology for the successive glaciations. It is now possible to trace a sequence of glaciations and interglacial periods in the East Midlands and elsewhere, but we remain very uncertain to which of these glaciations the various boulder clays of the East Midlands belong. To a certain extent these problems are interdependent, but the progress of the last fifty years shows that an advance in one field need not necessarily lead to progress in the other. The most important chronological evidence is the discovery and dating of an interglacial deposit exposed in section, and where the deposit is under or overlain by a boulder clay the boulder clay can be dated too. The difficulty in applying such observations to the subdivision of the boulder clays forming the land surface away from the section concerned is that there is no certain method of identifying the boulder clay elsewhere. Unless the boulder clay can be identified by means of its own characteristics no progress is possible. The traditional technique has rested on the lithology of the boulder clay and, more recently, on the analysis of the erratic content of the drift(1). However, it has long been known that a sheet of drift will vary greatly from place to place and these methods of correlation can never be wholly reliable.

Various other techniques have been suggested for distinguishing between different boulder clays. In the United States spectacular success has come from using the varying depth of decalcification and other chemical alteration on boulder clays of different ages(2). There have only been a few observations of depth of decalcification of drifts in this country; these give shallower depths and consequently less marked and less definitive contrasts from one deposit to another(3). Heavy mineral analysis was used by Solomon with considerable success in a restricted area along the North Norfolk coast(4), although the variability of the deposits makes the method hazardous. Moreover, later boulder clays almost invariably include material from older drifts overrun by the ice-sheet, giving additional uncertainty. The method has been tried by the present writer in Essex with indifferent success; as with estimates of the erratic content it is likely to be closely related to lithological variations within the deposit.

Recently West and Donner have adopted another American technique depending on the orientation of the stones in the boulder clay(5). These stones show a 'preferred orientation' in the direction of movement of the ice sheet that formed the deposit, so that if the

(1) Baden-Powell, D. F. W., "The chalky boulder clays of Norfolk and Suffolk", *Geol. Mag.*, 85, 1948, p. 279.

(2) Flint, R. F., "Leaching of carbonates in glacial drift and loess as a basis for age determination", *Journ. Geology*, 57, 1949, pp. 297-303.

(3) West, R. G., and Donner, J. J., "The glaciations of East Anglia and the East Midlands: a differentiation based on stone-orientation measurement of the tills", *Quart. Journ. Geol. Soc.*, 112, 1956, p. 69.
Clayton, K. M., "Some aspects of the glacial deposits of Essex", *Proc. Geologists' Assoc.*, 68, 1957.

(4) Solomon, J. D., "The glacial succession on the North Norfolk coast", *Proc. Geologists' Assoc.*, 43, 1932, p. 241.

(5) Donner and West, *vide supra*.

movements of successive ice sheets are contrasted, it should be possible to recognise two distinct deposits by this method. As irregularities in the sub-drift surface will influence the local movement of an ice-sheet, it is important to restrict observations to those areas where the sub-drift surface is reasonably smooth. Since most of the measurements made by West and Donner came from existing sections and not all of these are ideally located, it is likely that some of their orientations are atypical.

During the course of the Geological Survey of Lincolnshire in the 1880's, A. J. Jukes-Browne surveyed the Lincolnshire Wolds. He observed that there were two boulder clays which he was able to separate on lithological grounds, but he was also able to observe important contrasts in the form of the two deposits. In the first place, one was clearly older than the present valleys and dissected by them, while the other extended into the valleys and must have been deposited since their formation. Secondly, while the surface of the older deposit was featureless, the younger deposit rose into 'irregular ridges, mounds and hummocks'(1). This difference was used by W. B. Wright as a basis for subdividing the drifts of the British Isles, and he termed the two deposits the Older and the Newer Drift(2). It is probably not too much to claim that this concept remains the most important basis for subdividing the boulder clays of the British Isles. The contrast is morphological, and the time interval between the deposits is indicated by the denudation that occurred after the Older Drift was deposited and before the advance of the ice-sheet that deposited the Newer Drift. Yet despite the importance and the simplicity of this division, little has been done to trace in the field the boundaries of the Older and Newer Drift, tentatively mapped by Wright(3). In Oxfordshire and Buckinghamshire the limit of the Older Drift, the southern limit of glaciation in this country, is still unmapped by the Geological Survey, while it is only through the work of J. K. Charlesworth and L. J. Wills that the limit of the Newer Drift has been defined more closely(4). It is here hoped to trace the boundary of the Newer Drifts in the East Midlands, and to consider some of the problems raised by the morphology of these drifts.

The boundary of the Newer Drift has only been clearly defined along the eastern edge of the Lincolnshire Wolds, where the mapping of Jukes-Browne has been accepted by Wright and Charlesworth(5). It appears that it was the lithological contrast between the Chalky boulder clay and the brown or purple coloured Hessle boulder clay that first drew Jukes-Browne's attention to the difference in age of the two deposits. However, it is only the morphological differences between the two deposits that show that they are in fact separated by a period of time, and that one of the boulder clays is very much older than the other. A small part of the area of the Lincolnshire Wolds is shown in Figure 1.

(1) Jukes-Browne, A. J., etc., "The geology of part of East Lincolnshire", *Memoirs Geological Survey*, 1887, p. 79

(2) Wright, W. B., *The Quaternary Ice Age*, 2nd. ed., 1936.

(3) Wright, W. B., *vide supra*, p. 95.

(4) Charlesworth, J. K., "A tentative reconstruction of the successive margins of the Quaternary ice-sheets in the region of the North Sea", *Proc. Roy. Irish Acad.*, 40, 1931, p. 67.

Wills, L. J., "The Pleistocene history of the West Midlands," Presidential Address, Section, C., *British Association*, 1937.

(5) This area is at present under investigation by A. Straw, and his detailed results, in general, confirm the work of Jukes-Browne. (See article p. 41 in this issue—Eds.)

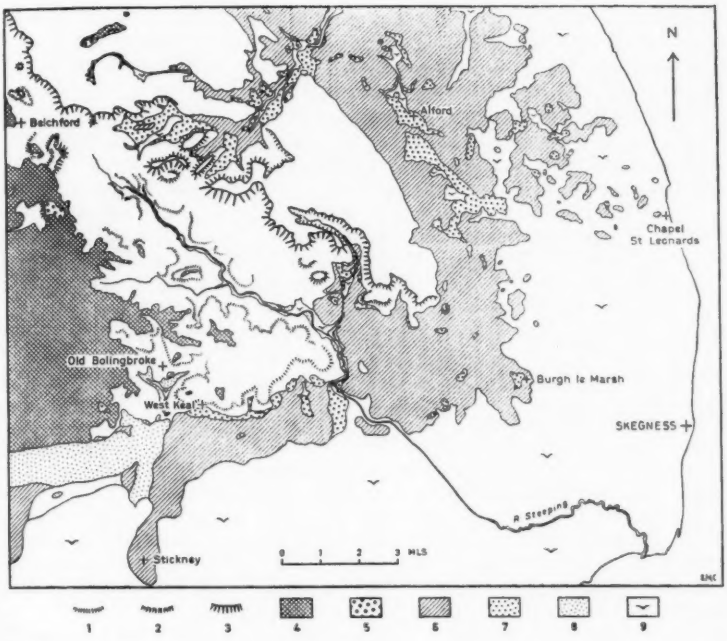

Fig. 1.

The southern part of the Lincolnshire Wolds.

Key: 1. Spilsby Sandstone scarp. 2. Tealby Limestone scarp. 3. Chalk scarp. 4. Older Boulder Clay. 5. Older Glacial Gravel. 6. Younger Boulder Clay. 7. Younger Glacial Gravel. 8. Fen Gravel. 9. Alluvium.

It will be seen that the Older Drift, the Chalky boulder clay, is found as surviving remnants of a formerly considerably more extensive sheet of drift. Since this Older Drift was deposited, processes of normal erosion by running water have cut a series of valleys, and the drift now survives in patches on the ridges and spurs between these valleys, as near Old Bolingbroke. In contrast, the Newer Drift, the brown and purple coloured material, occurs as a continuous sheet (except where partially covered by later alluvium) and is unbroken by the present valleys. In addition, the Newer Drift extends in tongues up the present valleys, showing that they were formed before the Newer Drift glaciation and that remarkably little erosion has occurred since.

This contrast in the relationship of the two drift deposits to the present river valleys of the area is conveniently referred to as a contrast in the 'attitude' of the two deposits. The contrast in attitude is reinforced by the second characteristic noted by Jukes-Browne for, while the surface of the older drift has been smoothed over a long period of time, the irregular surface of the Newer Drift seems 'hardly modified by any agencies since the accumulation of the materials which compose it'(1).

(1) Jukes-Browne, A. J., *vide supra*, p. 79.

During the 70 years since the Memoir on East Lincolnshire was published, this second characteristic, described by American glaciologists as a difference in 'topographic expression', has come to assume pride of place in the identification of the Newer Drift.

The reliance on the single characteristic of fresh topographic expression as a means of identifying the Newer Drift leads to difficulties when an attempt is made to trace the limit of the Newer Drift. It soon appears that there is no well defined limit to the irregular surface features of the drift, but rather that as the limit of the deposit is reached the surface features gradually become smoother. W. B. Wright was well aware of this when he wrote that 'just as there are degrees of weathering and denudation in the Older Drift, so there are in the Newer, and it becomes questionable whether the actual line of separation which . . . has . . . been . . . traced is really more important than others of a similar nature which might be drawn within or without it'(1). The problem may be illustrated by the various limits proposed for the Newer Drift in southeast Lincolnshire (Fig. 1). Professor Swinnerton has traced three features in the low-lying and generally brown-coloured drift east and south of the Wolds which appeared to him to mark stages in the retreat of the ice-sheet(2). The outermost runs southwards as a low, smooth ridge from West Keal, through Stickney to Sibsey. The second is a broad feature northeast of the River Steeping, perhaps best referred to as the Burgh le Marsh stage. The third appears as a complex ridge which reaches the coast at Chapel St. Leonards (Fig. 1). Apparently basing his decision on a combination of lithology and what we have termed 'attitude', Professor Swinnerton includes all these features in the Newer Drift. In contrast, Professor Charlesworth took the Burgh le Marsh feature as the limit of the Newer Drift(3). Although his criterion is largely that of topographic expression, it appears that he was principally influenced by the position of the brown boulder clay at Hunstanton. While this Burgh le Marsh limit gives a smooth curve to the ice-front, in many ways the Chapel St. Leonards feature is a more satisfactory limit to the hummocky drift.

It is clear that any attempt to trace a boundary based on the two characteristics of the Newer Drift, 'attitude' and 'topographic expression', will result in meaningless compromise. The two characteristics are found in combination in the classic area east of the Lincolnshire Wolds but, further to the south and west is a sheet of drift which has a smooth surface, yet in its relation to the present valleys has the characteristics of Newer Drift. When an attempt is made to trace the boundary of the drift characterised by an attitude typical of the Newer Drift, although with a smooth surface, a considerable extension of the area occurs. As we have already indicated, Professor Swinnerton placed the low-lying drift as far west as Stickney in the Newer Drift. The relationship here is particularly well marked, for the continuous sheet of boulder clay banked to a height of about 100 feet O.D. against the steep slope below the Spilsby sandstone outcrop, contrasts strongly with the patches of Older Drift lying above the 250 foot contour. To the west and southwest the drift disappears beneath more recent deposits of peat, alluvium and gravel, and eleven miles of fen separate the boulder clay at Sibsey from the nearest boulder clay at Heckington, east of Sleaford.

(1) Wright, W. B., *vide supra*, p. 91.
(2) Swinnerton, H. H., *The Geology of Lincolnshire*, 1949, Fig. 19, p. 97.
(3) Charlesworth, J. K., *vide supra*.

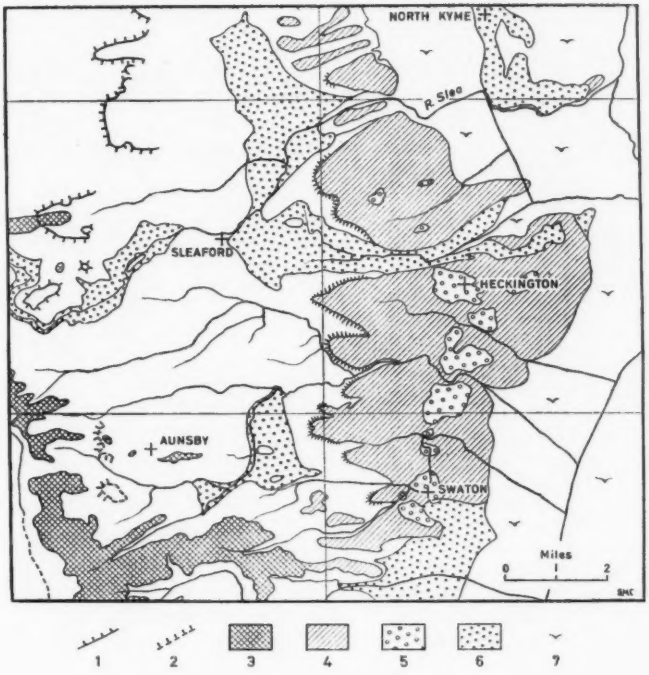

Fig. 2.
The fen edge east of Sleaford.

Key: 1. Great Oolite scarp. 2. Cornbrash scarp. 3. Older Drift (Boulder Clay and Glacial Gravel). 4. Younger Boulder Clay. 5. Younger Glacial Gravel. 6. Fen Gravel. 7. Alluvium.

The scarp developed by the erosion of the Younger Drift is indicated by hachuring.

In the Southwest Lincolnshire Memoir, Jukes-Browne refers to the Fen edge east and southeast of Sleaford which he mapped a few years before the East Lincolnshire sheet(1). His account of the distribution of the glacial drift is worth quoting here. 'A glance at Sheet 70' (of the Old Series One Inch Geological Map) 'will show the difference in behaviour of the two boulder clays (Fig. 2). The Older boulder clay spreads over the high ground in the south and centre of the map, but is not found north of the Ancaster valley. The Newer clay keeps to comparatively low levels and appears to have formed a sort of terrace or platform between the Fenland and the highland or heathland to the west; exactly as its countertype does in East Lincolnshire between the marshland and the Wolds'(2). At first sight, if the attitude of the drift sheet

(1) Jukes-Browne, A. J., "Geology of the Southwest part of Lincolnshire", *Memoirs Geological Survey*, 1885.

(2) Jukes-Browne, A. J., *vide supra*, 85.

is to be the criterion, this boulder clay clearly belongs to the Newer Drift. Yet there are some differences between this boulder clay and the Newer Drift of East Lincolnshire. As Jukes-Browne observed, the western border of the deposit has been cut back and now presents a marked slope or scarp to the west. This is indeed a scarp and it has receded to the east with the excavation of what may perhaps be described as a subsequent vale on the underlying Oxford Clay. The result is that deposit now extends towards the higher land, not along the valleys, but along the intervening spurs (Fig. 2). There is evidence here for the same gradual transition southward in the attitude of the boulder clay as is shown by the change in topographic expression in East Lincolnshire. However, there remains the great contrast which Jukes-Browne perceived between this younger drift and the Older Drift of the upland to the west. Thus, around Sleaford the Older Drift is preserved on a few spurs above 200 feet O.D., while the Newer Drift forms this virtually continous cuesta-like feature, five miles at its widest and some dozen miles long.

Further fieldwork will be required to trace this Newer Drift boundary further south, for the geological maps available are not of the high standard of mapping characteristic of Jukes-Browne. It is probable that the ice-sheet which deposited the boulder clay east of Sleaford spread out to fill most of the Fen depression, and that it was usually, if not everywhere, contained by the surrounding bluffs. Reconnaissance mapping of the area south of Peterborough suggests that Newer Drift occurs along the Fen edge between Stilton and Wood Walton (Fig. 4) and is separated by a bluff cut in the Oxford Clay from the Older Drift which forms the plateau between the Fens and the River Nene(1). This low level deposit is probably at the southwest limit of advance of the Newer Drift ice-sheet, but the boundary further east is as yet untraced.

In the vale drained by the Ouse and Trent, a similar arrangement of boulder clays is seen. The Escrick moraine (Fig. 4) is normally taken as the limit of the Newer Drift, and this feature seems to mark the southern limit of the hummocky drift. Other arcuate features to the north suggest further retreat stages, much as in Lincolnshire, while to the south any further deposits of boulder clay are buried beneath outwash deposits and alluvial warp. It is this absence of boulder clay immediately to the south that has emphasised the importance of the Escrick feature. However, as in Lincolnshire, there is evidence that the same ice-sheet earlier covered a greater area. The Geological Survey have described an early phase of the Newer Drift from near Wetherby, to the southwest of the Escrick moraine (2), and the boulder clay at the foot of the Chalk and Rhaetic scarps between Market Weighton and Pocklington (Fig. 4) suggests a similar relationship(3).

Well to the south of Escrick occur deposits of boulder clay lying low in the present vales and very little dissected, but with the smooth surface characteristic both of the outlying Newer Drift deposits and of the Older Drift. The most important of these deposits of boulder clay in the Vale

(1) This area urgently requires detailed remapping. In places there is a difference of one or two miles between the drift limit mapped on the published Old Series sheet (52 N.E.) and that mapped on the later manuscript 6 inch sheet of the same area.

(2) Edwards, W., etc., "Geology of the district north and east of Leeds", *Memoirs Geological Survey*, 1950.

(3) *Geological Survey*, New Series One Inch Map, Sheets 71 and 72.

of Trent is that lying between Gainsborough and Lincoln (Fig. 3), a smooth sheet of drift some fifteen miles from north to south and a maximum of six miles wide. Over most of this area the boulder clay surface lies between 25 and 90 feet, while the base is generally between 20 and a little over 50 feet O.D. These altitudinal observations enable us to relate this boulder clay to the terraces of the River Trent which are excellently preserved between Newark and Lincoln.

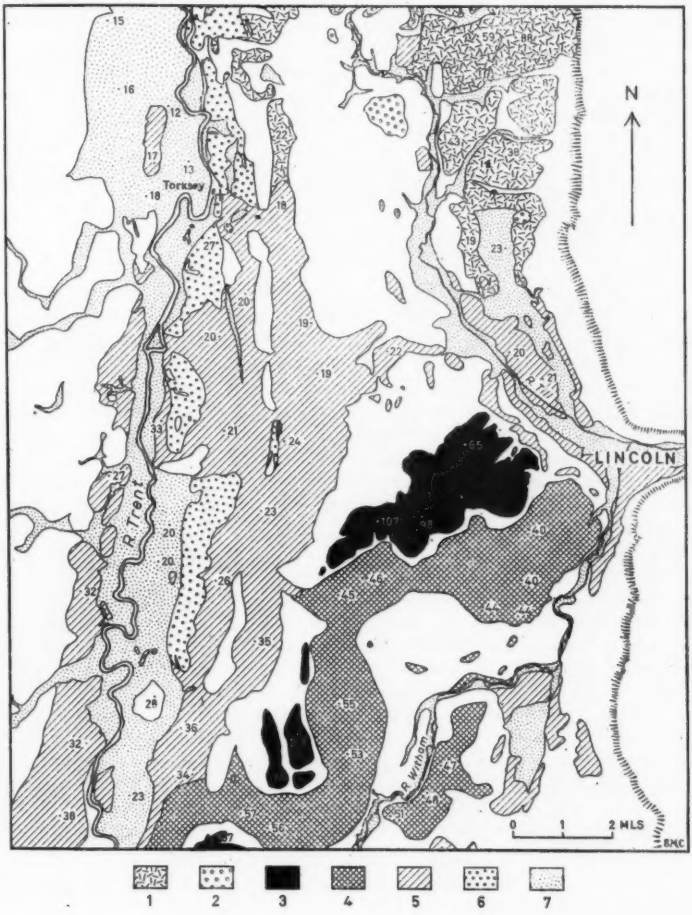

Fig. 3.

The area west of Lincoln.

Key: 1. Boulder Clay. 2. Glacial Gravel. 3. Hilton Terrace. 4. Beeston Terrace. 5. Floodplain Terrace. 6. Blown Sand. 7. Alluvium.

Surface altitudes are in feet O.D.

Three former courses of the River Trent towards the Lincoln Gap are preserved in three river terraces (Fig. 3). The highest of these consists of patches of gravel on the Eagle Hills, northeast of Newark, reaching a maximum height of 120 feet O.D., and declining eastwards to about 65 feet O.D. It is likely that this range of height includes two or more substages, but they are conveniently grouped as the Hilton terrace of the Trent(1). To the south of these hills is a later spread of gravel which forms part of the succeeding Beeston terrace of the Trent. The gravels forming the Beeston terrace have a surface height of almost exactly 60 feet east of Newark and they fall to 40 feet southwest of Lincoln. The solid floor on which these gravels rest and which was cut before they were deposited (or at the same time as they were deposited) falls from just above 50 feet in the west to about 25 feet in the east. Finally, the youngest terrace of the Trent, the Floodplain terrace, swings in an arc to the north of the Eagle Hills, with a surface level falling from 35 feet to 20 feet O.D. The gravels of this terrace pass beneath the present alluvium of the Rivers Trent and Witham, and it was probably during the aggradation of the Floodplain terrace that the River Trent found its way to the River Humber(2).

It has been shown that the Hilton terrace of the Trent is later than the last advance of the Older Drift glaciations, the advance which deposited the extensive sheet of Chalky boulder clay in the Middle Trent valley(3). From the altitudes of the terraces and the boulder clay, shown on the map (Fig.3), it will be seen that west of Lincoln the Hilton terrace of the Trent rests on an older and higher surface than that which underlies the boulder clay to the north. The sub-drift surface north of the Eagle Hills, with an elevation between 20 and 50 feet, is clearly related to the surface underlying the gravels of the Beeston terrace to the south of the hills, for that surface also declines towards the Lincoln gap from 50 to about 25 feet. From the local evidence alone it is not clear whether the boulder clay itself is later or earlier than the aggraded gravels of the Beeston terrace. The point is not very important for the two deposits are clearly of very similar age. The boulder clay can be very little younger than the Beeston terrace, for the gravels of the later Floodplain terrace overlie the boulder clay east of Torksey (Fig. 3). The significant point is that the relationship between the boulder clay and the Trent gravels confirms that the boulder clay in this area is younger than the Chalky boulder clay of the Older Drift. In addition, the preservation of the Hilton gravels, which are older than the boulder clay lying north of the Eagle Hills, suggests that the ice-sheet concerned did not extend any further to the south.

---

(1) Clayton, K. M., "The glacial chronology of part of the Middle Trent basin", *Proc. Geologists' Assoc.*, 64, 1953, p. 198.

(2) Jukes-Browne, A. J., "On the relative ages of certain river valleys in Lincolnshire", *Quart. Journ. Geological Soc.*, 39, 1883, p. 609.

(3) Clayton, K. M., *vide supra*, p. 202.

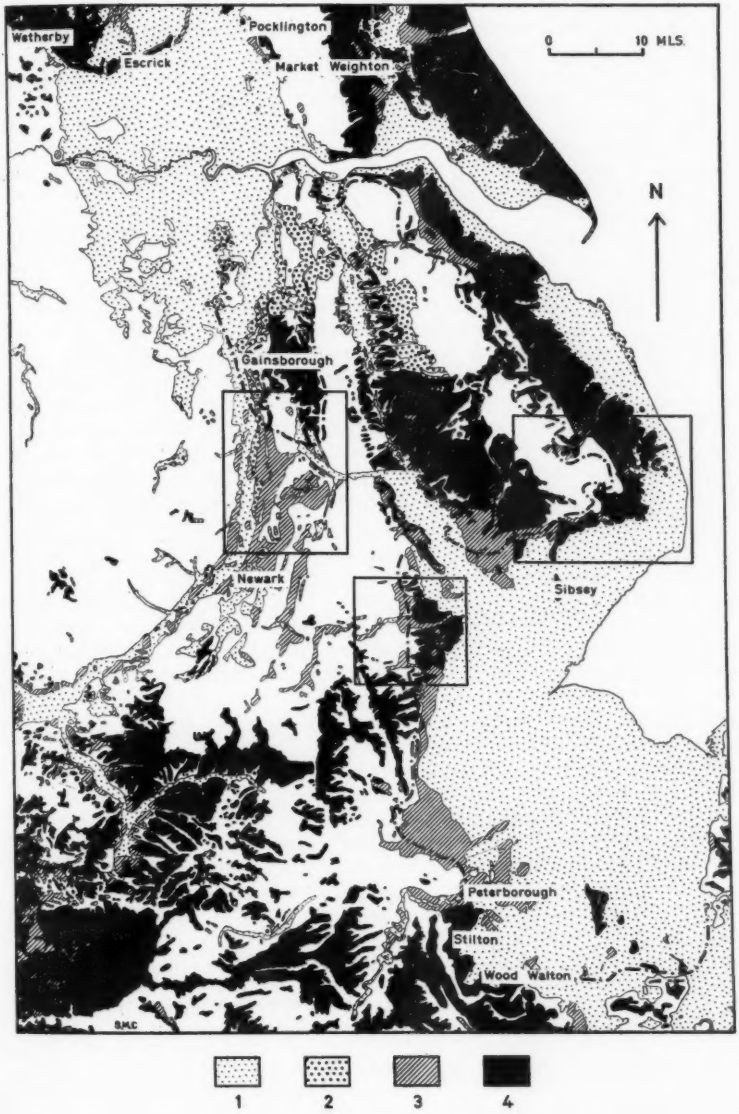

Fig. 4.

The drift geology of part of eastern England.

Key: 1. Alluvium. 2. Blown Sand. 3. Glacial Gravel, River Gravels and Fen Gravel. 4. Boulder Clay.

The rectangles indicate the areas covered by Figures 1—3. The approximate limit of the Newer Drift, located on the basis of the attitude of the deposits, is shown by the dash-dot line.

If this interpretation of the field evidence is accepted, it follows that the existing subdivision of the boulder clays of the East Midlands into Older and Newer Drift is seen to be unsatisfactory. But that such a division is possible and of great value is clear. It is merely that adequate care must be taken to choose the criteria on which to base a division; while the criteria, once chosen, must be carefully applied. The true limit of the Newer Drift is to be found well beyond the boundary traced by Wright and Charlesworth, while their boundary serves to distinguish only one of a number of subdivisions characterised by increasingly fresh surface topography. On Figure 4 an attempt is made to trace the boundary of the Newer Drift on the basis of the 'attitude' of the deposits of boulder clay. It may be objected that it is the drift which displays both of the characteristics noted by Jukes-Browne that should be termed the Newer Drift and that the drift beyond that boundary is intermediate in age between the Newer Drift and the Older Drift. However, the difference in age between the two deposits is most convincingly shown by the long period of denudation which separated the two glaciations, rather than by the fresh surface of the younger part of the Newer Drift. On those grounds it seems preferable to regard what we have called the attitude of the deposit as the criterion to be used in separating the Older and Newer Drifts, and to regard the differences in topographic expression merely as a basis for further subdivision of the Newer Drifts.

SOME GLACIAL FEATURES OF EAST LINCOLNSHIRE

ALLAN STRAW

The glacial deposits of East Linclonshire were last described in detail by officers of the Geological Survey in 1885, 1887, 1888 and 1890(1). Since then, F. W. Harmer(2) and H. H. Swinnerton(3) have given broad accounts of the various drifts, and G. W. Lamplugh(4), C. F. B. Shillito(5) and C. R. Twidale(6) have discussed particular topics. This paper presents some preliminary results of an intensive survey of the geomorphology of the area, carried out during the past three years.

The drift deposits overlying the Jurassic and Cretaceous rocks of East Lincolnshire can be broadly divided into Older and Newer Drifts.

THE OLDER DRIFT

The Older Drift, where it is thick enough to be mapped, lies both on the Chalk Wolds and to the west, and by its composition can be subdivided into three types—Intensely Chalky, Chalky-Jurassic and Chalky-Neocomian. The former occupies the central Wolds to 450 feet O.D. (Fig. 2), although erratics belonging to this or an earlier glaciation can be found above 500 feet. Composed almost entirely of Chalk debris, it covers the western flank of the southern Wolds until it reaches the Fen deposits. There are outlying patches to the east of the main deposit both west of the river Lymn, and east of the Chalk escarpment at Maidenwell(7).

The Chalky-Jurassic drift occurs throughout the Central Vale of Lincolnshire, but south of Tealby, and near the Wolds, it appears to pass laterally into the Chalky-Neocomian type. The drift is fragmentary in the north of the Vale, due to dissection by the river Ancholme and its tributaries, but south of Market Rasen and east of the river Langworth, it forms a continuous sheet some 30 to 50 feet thick. The matrix is derived from the underlying Oxford and Kimmeridge clays but most of the erratics are of Chalk and flint.

(1) Memoirs Geological Survey, Old Series : C. Reid, *Geology of Holderness*, 1885 ; A. J. Jukes-Brown, *Geology of East Linconshire*, 1887 ; W. A. E. Ussher and others, *Geology of the Country around Lincoln*, 1888 ; W. A. E. Ussher, *Geology of North Lincolnshire and South Yorkshire*, 1890.

(2) F. W. Harmer, "The Distribution of Erratics and Drift", *Proc. Yorks. Geol. Soc.*, Vol. XXI, 1928, p. 79.

(3) H. H. Swinnerton and P. E. Kent, *The Geology of Linconshire*, Lincolnshire Naturalists' Union Brochure, 1949.

(4) G. W. Lamplugh, "Kelsey Hill, Kirmington and other Drift problems", *Trans. Hull Geol. Soc.*, Vol. VI, Pt. V, 1922-25, p. 3.

(5) C. F. B. Shillito, "The Kirmington Fiord", *Trans. Hull Geol. Soc.*, Vol. VII, 1937, p. 125.

(6) C. R. Twidale, "Longitudinal Profiles of Some Glacial Overflow Channels", *Geog. Journ.*, Vol. CXXII, 1956, p. 88.

(7) For place names mentioned in the text see Figure 1.

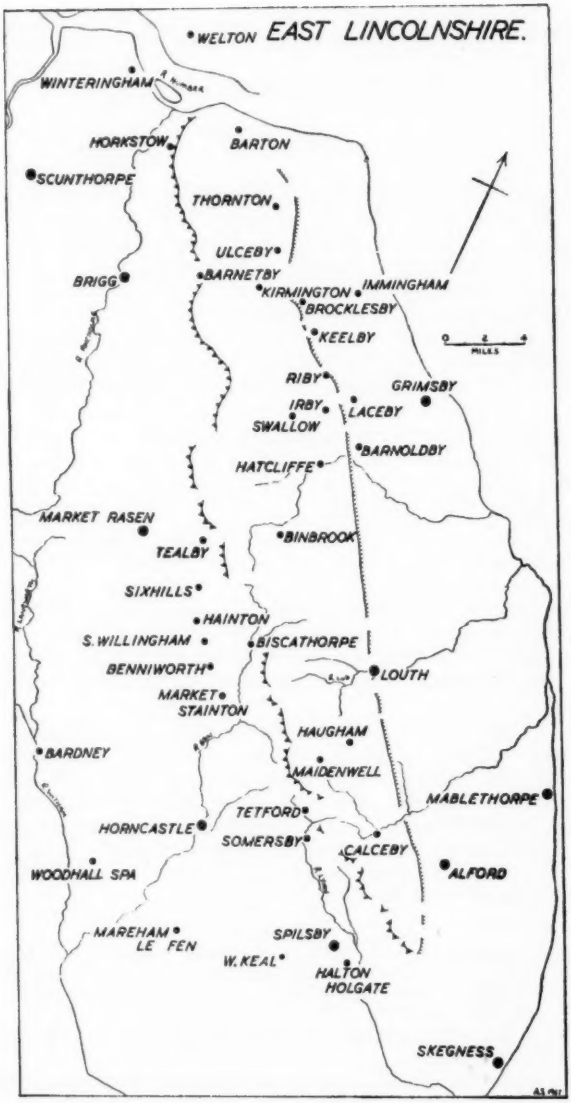

Fig. 1

The Chalky-Neocomian drift, not shown separately on Figure 2, appears to have originated as the lateral moraine of the ice associated with the Chalky-Jurassic drift, and consists of material scoured from the scarp face, so that Lower Cretaceous sands and clays are the main

constituents. Outliers occur at over 400 feet O.D. on the escarpment east of Market Rasen, but south of Sixhills this drift passes beneath the Intensely Chalky boulder clay. It may reappear between Bardney and Woodhall Spa, but in a less raw state than further north, as the individual constituents are more thoroughly mixed together. Nevertheless, large blocks of Spilsby Sandstone have been found at Bucknall. The brown and grey boulder clays east of Sleaford may well be of this type although they show closer affinities to the drifts lying east of Lincoln, around Cherry Willingham and Reepham.

The Intensely Chalky boulder clay partly overlies the Chalky-Jurassic till around Hainton and Benniworth, but just west of these villages, and towards the south, the surface junction of these two deposits is clearly and easily defined. The field relationships of the drifts suggest that the ice sheets were contemporaneous, and topographic considerations indicate that the western ice entered the area from a little west of north, while the eastern ice moved due south on to the Wolds, crossing into the Fen district over the valleys of the rivers Bain and Lymn.

In the vicinity of Biscathorpe, South Willingham and Market Stainton, and immediately beneath the Chalky boulder clays, is a large outwash fan, consisting mainly of coarse flint gravel, with a matrix of Lower Cretaceous sands. The material becomes progressively finer to the south and rests on an uneven surface of Spilsby Sandstone and Claxby Ironstone. This fan indicates a somewhat prolonged halt by the ice of the Intensely Chalky drift at about the Bain/Binbrook valley watershed, and may have received detritus from the western ice which lay near Hainton and South Willingham.

On the east side of the central and southern Wolds, the Older Drifts do not occur below about 300 feet O.D., but north of the Barnetby Gap, Older Drift erratics, mainly quartzites and sandstones, can be found down to 200 feet. These erratics and patches of Older Drift are preserved on relatively flat areas which when mapped appear to be relics of base-levelled surfaces at 400-420 feet, 300-330 feet, and 180-220 feet. These surfaces, and the Older Drift which lies on them, are dissected by the Wold valleys and are truncated by a marine cliff, which forms the eastern and southern limit of the Wolds. The associated marine plane was developed at about present-day sea-level.

The Newer Drift

The Newer Drift lies on the marine plane and is banked against the cliff, overriding it in many places. The average thickness of this drift is 60 to 80 feet, but certain borings have proved much greater accumulations. Between Kirmington and Immingham, numerous bores have passed through up to 240 feet of silts, tills and gravels in order to reach the Chalk, indicating the presence of a deep channel cut into and across the marine plane. Other buried channels probably exist, connecting with the larger Wold streams such as Hatcliffe Beck, the River Lud, and Calceby Beck.

The drift is composed of layers of boulder clay, brown or greyish-brown in colour, separated by intermittent seams of sand and gravel. Frequently a purplish tinge is apparent when the tills are wet. Variations in colour seem to be due to partial decalcification and oxidation, and several sections have been observed where tough dark brownish-grey clays pass smoothly up into lighter reddish-brown loams, clays and silts.

Colour is therefore no accurate aid in the correlation of various sheets of till, but generally the lower clays are greyer and darker, while upper members are lighter and browner. Both groups provided reddish-brown stony loams and clays after weathering.

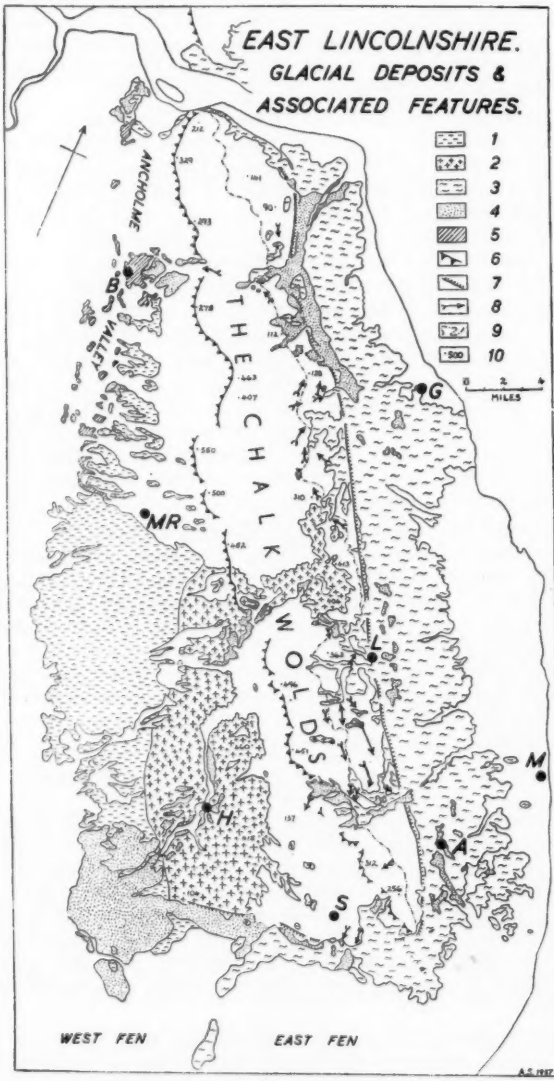

Fig. 2

Key: 1. Chalky-Jurassic drift. 2. Intensely Chalky drift. 3. Newer Drift. 4. Gravel. 5. Low Level Deposits of the Ancholme. 6. Chalk escarpment. 7. Marine cliff. 8. Spillway. 9. Maximum westerly extension of Newer Drift on the Chalk Wolds. 10. Spot height.

Place names are given in full on Figure 1.

The matrix shows rapid variation from compact fine clay to soft silty sand, and changes in the type and amount of erratics occur locally. In sharp contrast with those of the Older Drifts, the majority of the erratics are of extraneous origin. Many boulders are derived from the sedimentary rocks of the North Pennines and northeast coast, and from Scottish and Cheviot igneous and metamorphic rocks. Material of Scandinavian origin is distinctive though in small proportion. Chalk is a variable constituent, and is concentrated in the lower layers, sometimes to the virtual exclusion of other erratics. Partial decalcification of the drifts accentuates the contrasts, but this can usually be recognised, for the flint associated with the Chalk is not destroyed.

The intercalated sands and gravels are derived from the tills, but larger surface accumulations near and within the Wolds frequently contain an increased proportion of chalk resulting from the excavation of meltwater channels.

The deposition of the Newer Drift took place in at least two stages, separated by a period of erosion of interstadial character. The earlier of the two phases at present recognised was the maximum, with ice reaching 300 feet O.D. just west of Louth, but rather lower to the north and south. This ice entered the Humber Gap as far as Horkstow, Winteringham and Welton (Yorkshire), closed the Barnetby Gap, and is believed to have extended as far south as Boston and Hunstanton, creating lake conditions in the Humber, Witham and Fen areas. This considerable southward extension as compared with the Vale of York, is believed to be due to lateral pressure exerted by an ice mass to the east and northeast. The limited penetration of the Humber and Fen gaps is probably due in part to rapid calving of the ice into the lakes, and various fine gravels and laminated clays in the Ancholme valley and capping low interfluves southwest of Market Rasen give evidence of these conditions. In addition, a thick and extensive deposit of clean finely current-bedded sand occurs on Kirkby Moor, east of Woodhall Spa, at 80-90 feet O.D. Similar patches lie east of the Bain at Haltham Wood and Toft Hill. It is significant that this spread of sand and gravel is dissected by the Bain and other tributaries of the Witham, and further, that the terraces of both the Bain and the Witham occur almost wholly below the Kirkby Moor sands. East and southeast of Woodhall Spa, the higher Witham terrace is separated by a low bluff at about 50 feet O.D. from the adjacent sands.

Spillways

The ice also gave rise to spillway systems on the east side of the Wolds, directed north and south, finding escape through the Barnetby and Calceby gaps. Outwash fans of sand and gravel associated with the release of meltwater westward occur around Brigg and Tetford. South of Tetford, the water escaped towards Somersby over a low watershed, effecting a permanent diversion of Tetford Beck into the river Lymn. Subsequently this water followed the ice edge once more, leaving sand and gravel deposits between Halton Holgate and West Keal, and entered the Fen area.

A second and lower system of spillways associated with a measure of retreat of this ice can be determined, while south of Louth a third series is apparent. The ice then appears to have withdrawn completely

from the Wolds towards the North Sea, allowing a period of erosion over most of East Lincolnshire. Within the Wolds, the drifts were partially removed from the lower parts of the valleys, and there was some modification of the form of the spillways.

A readvance then seems to have taken place, and the ice was forced into the deep, narrow valleys of the central Wolds, but not generally above 250 feet O.D. With restricted entrance to these valleys, this ice stagnated and decayed into blocks, with many instances of marginal diversion of streams of meltwater, as around Hatcliffe, Swallow, Irby and Riby. These spillways contrast markedly in form and position with those of the earlier stage. The earlier spillways are relatively shallow and wide, with uneven long profiles, and connect valley system with valley system. The younger ones are deep, abrupt, and occur within valley systems ; most of them are true "in and out" channels, associated closely with the decaying blocks of ice.

This belief that the spillways of the Wolds were formed during two separate phases of ice advance and retreat, is contrary to the views of C. R. Twidale in his work on the north central Wolds.(1) He postulated one ice advance and suggested that all the channels could be resolved into sequences created by intermittent retreat of the ice. This possibility ignores the great contrast in form between the two groups of channels, the older ones having undergone considerable modification under periglacial and interstadial conditions. In some of these earlier channels, erosion has given rise to slight reversed gradients in the intake section, so that the lip of the spillway tends to move downstream as a gentle "hump". In these instances, pre-Newer Drift drainage is not entirely responsible for "humped" longitudinal profiles. One case where reversal of flow is probable is the Orgarth spillway near Haugham, three and a half miles south of Louth.

Retreat of Newer Drift

As ice decayed in the Wold valleys, the main mass of ice may have pulled away from the hills as in the earlier stage, for morainic lines occur at intervals across the Marsh. There was a prolonged halt in the north of the area, around Barnoldby-le-Beck, Laceby, Keelby and Brocklesby, giving rise to large accumulations of strongly current-bedded sands and gravels as kame-terraces. Slight retreat from this position seems to have guided meltwaters north past Ulceby and Thornton Curtis, leaving spreads of gravel at 60 to 30 feet O.D., abutting against, and lapping round, the kame-terrace gravels.

Either a further prolonged halt in the retreat of this ice, or a later readvance, was responsible for the southerly diversion of the river Humber, the initiation of the river Hull, and the accumulation of the Kelsey Hill—Keyingham gravels.

The place of the Kirmington deposits in the stratigraphy of the Newer Drifts is difficult to establish, and it is felt that too much significance has previously been placed on them. The "shingle", which overlies the fossiliferous and plant-bearing deposits, is composed mainly of well-rounded flints, but many of these are shattered and no traces of

(1) C. R. Twidale, *op. cit.*

bedding can be distinguished. The matrix is coarse and gritty, while erratics are restricted to a few quartzites. A similar but thinner deposit of rounded chalk pebbles occurs near the exit of Mere Hill spillway, one mile southeast. This deposit exhibits the same structure, and occurs at exactly the same height as the Kirmington "shingle", and the two deposits appear closely connected with the spillway, although the Kirmington gravels have undergone subsequent reworking by congellit-urbation. The possibility exists that the whole of the laminated deposits at Kirmington may be of lacustrine origin.

Relation of Older and Newer Drift

An immense period of erosion occurred between the deposition of the Older and Newer Drifts. The Older Drift is weathered to a depth of five feet, and in many places the matrix has been completely removed, leaving thin, but fairly heavy soils with a profusion of angular flints and some erratics. Considerable dissection of about 75 to 100 feet accompanied this weathering, with the removal of much of the drift north of Binbrook and south of Louth. This dissection is due to a rejuvenation of the streams initiated by a fall of base-level from that operating before deposition of the Intensely Chalky boulder clay. The Older Drifts are preserved only on the interfluves and upper valley slopes, not descending below 200 feet O.D. on the east side of the north Wolds, nor below 300 feet south of the Barnetby Gap. The marine cliff was developed at the new base-level, and it truncates not only the relic surfaces and pre-existent valley systems, but also the Older Drift. This is well seen north of Louth, and between East Keal and Mareham-le-Fen in the south. The morphological characteristics of the cliff and the associated marine plane make it highly improbable that they can be any other than of the same age as those in Holderness.

In certain localities, where the Older Drift may have descended below 300 feet, it seems to have been incorporated in or overlain by the Newer Drift. Thus near Welton-le-Wold and Wold Newton, the two Drifts are either juxtaposed or occur at the same level separated only by a shallow dry valley.

Towards the end of the period, with falling base-level, the Humber and Ancholme, Witham, and other smaller streams became partially regraded, and were either incised into the marine plane or caused increased dissection of the Older Drift in central Lincolnshire.

Summary and Conclusions

The broad conclusions permit the recognition of two glacial periods separated by an interglacial. The first is Older Drift, with the Chalky boulder clays on, and west of, the Wolds, provisionally correlated with the Gipping drifts of East Anglia.

The interglacial was a period of erosion with sea-level approximately equal to the present, rejuvenating the Wold valleys and producing the marine plane and cliff on the east.

With the approach of Newer Drift ice, sea-level fell and the buried channels were cut, to be immediately covered by the Newer Drift. This was deposited in at least two stages, separated by a short period of weathering and erosion. Meltwater phenomena are associated with both of these stages, and show marked differences in morphology and situation, due to the disparity in age.

The writer wishes to acknowledge the receipt of financial assistance from the Research Fund of the University of Sheffield in respect of fieldwork carried out within the period 1954 to 1957. He also appreciates the advice and assistance kindly given by Professor D. L. Linton and other members of the staff in the Department of Geography, the University of Sheffield.

"THE VALLEY", ANCASTER: A LINCOLNSHIRE OVERFLOW CHANNEL?

D. R. MILLS and K. WARREN

Lincolnshire is a county characterised by drainage peculiarities; the great arc of the Witham, the massive water gaps of Lincoln and Ancaster, the deep cut channels of the Wolds. It has been suggested convincingly that the latter are glacial overflow channels, but no satisfactory mechanism to explain their peculiar form has been put forward.

In June 1956 members of the Nottingham University Departments of Geology and Geography made a study of a dry valley whose origin may be similar to the valleys of the Wolds. This feature is known locally as "The Valley" and lies to the south-east of Ancaster, a village between Grantham and Sleaford. In a mile it falls about 120 feet (between II and III, Fig. 1), from the Heath of the broad Lincoln Edge to the flat open floor of the Ancaster Gap (IV) now occupied by the insignificant Beck—a stream which in all conscience would need an "infinity of small increments" to have cut the valley in which it flows.

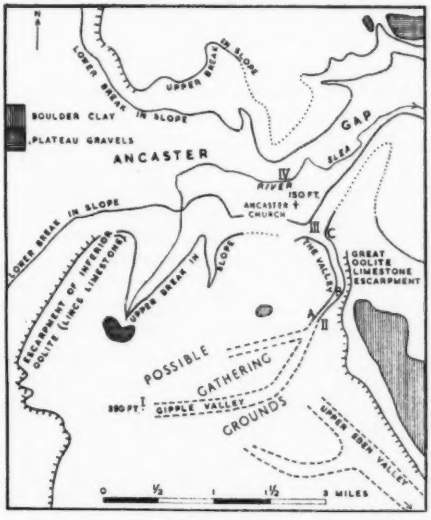

Fig. 1
Morphological sketch of the Ancaster district.

To the west of "The Valley" two normal heathland valleys run down to the floor of the Gap. These are characterised by open V-shaped contours, while "The Valley" is very different, being much more deeply incised. Figure 2 indicates the relatively steep longitudinal profile of "The Valley". This name in fact applies only to the steep lower part of a valley which in its gentle upper course is here called the Gipple valley, from the Gipple Farm and Cottages at its head (between I and II, Fig. 1).

"The Valley" is not a graded stream course. Three sudden drops of 5 to 10 feet in its long profile emphasise this lack of grading. At 'C' the drop is associated with a marked swing of the "flood plain" and of a terrace from the left side of the valley floor to the right (see Figs. 1 and 2). At 'A' the fall is associated with a smooth-sided, rounded hollow of diameter about 80 feet and depth 15 feet. This is separated from the valley by a low bar five to six feet high. It seems likely that this is an old quarry, for there are several large quarries in the area to the south of Ancaster. Undoubtedly the form of "The Valley" must have been modified by the transport of large amounts of stone. In contrast, the break of slope at 'B' seems to be due to relatively recent soil creep on the upper side of a hedge which runs obliquely across "The Valley" at this point.

Kent[1] has suggested that "The Valley" is a glacial overflow channel—even if noticeably different in form and scale from those in northern England. The height of this area is only about 200-225 feet O.D. compared with 250-350 and 500-900 feet respectively in the areas of the Lincolnshire Wolds and the North Yorkshire Moors where similar channels have been observed[2,3].

Certainly the cross profile of "The Valley" is suggestive of a glacial spillway, notably in transverse profiles 2 to 5 of Figure 2. Dense undergrowth on the right bank hampers exact survey, but "The Valley" in its mid-section can certainly be described as U-shaped, the U being most steep and narrow at the upper bend, and opening out more gradually downstream than upstream. This profile differs notably from the open V-profile of the two short parallel dry valleys a mile or so to the west.

This U-shape may be partly due to deposition. Between the two main bends the left bank and all but the lowest part of the floor are covered by debris containing both quartzite pebbles of Bunter Sandstone origin and limestone brash—that is, a gravel of probable glacial origin derived from the deposits lying to the north-west. The lowest part of the valley-floor contains limestone debris only, to a depth of at least four feet. Clearly deeper augering is necessary to determine if this limestone brash lies on top of the supposed fluvioglacial sandstone pebbles and possibly the debris from glacial lake deposits.

An absence of detailed geomorphological work in this area precludes any definitive statement of the date and mode of origin of "The Valley". A spillway cut by a relatively short period of flow is suggested by the short, steep and relatively shallow form[4]. Figure 2 shows that nowhere does the depth exceed 50 feet. Figure 1 indicates one possible gathering ground, from which water may also have escaped down the obviously misfit stream occupying Long Hollow and running to the south-south-east. Kent assumed that this, like "The Valley" and the Glen and upper Witham, was a marginal channel formed during a retreat stage and related to the boulder clay on ground to the east. Certainly the upper Eden valley merits further study, including augering.

(1) Kent, P. E., "Notes on the River Systems and Glacial Retreat Stages in South Lincolnshire", *Proceedings of the Geologists' Association*, 50, 1939, pp. 164-167.

(2) Twidale, C. R., "Longitudinal Profiles of some Glacial Overflow Channels", *Geographical Journal*, 122, 1956, pp. 88-92.

(3) Kendal, P. F., "A System of Glacier Lakes in the Cleveland Hills", *Quarterly Journal of the Geological Society*, 58, 1902, pp. 471-571.

(4) Swinnerton, H. H., and Kent, P. E., *The Geology of Lincolnshire*, Lincoln, 1949, frontispiece.

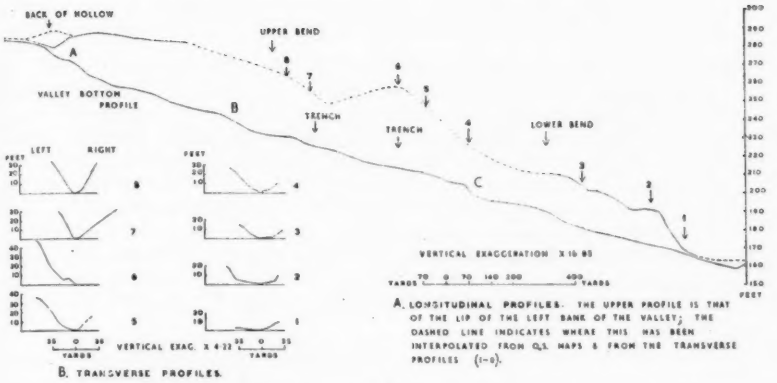
BACK OF HOLLOW
UPPER BEND
A
VALLEY BOTTOM PROFILE
B
TRENCH
TRENCH
LOWER BEND
C
VERTICAL EXAGGERATION X 10 85
LEFT
RIGHT
FEET
YARDS
VERTICAL EXAG. X 4 22
A. LONGITUDINAL PROFILES. THE UPPER PROFILE IS THAT OF THE LIP OF THE LEFT BANK OF THE VALLEY; THE DASHED LINE INDICATES WHERE THIS HAS BEEN INTERPOLATED FROM O.S. MAPS & FROM THE TRANSVERSE PROFILES (1-8).
B. TRANSVERSE PROFILES.

FIG 2 ANCASTER. "THE VALLEY"

If "The Valley" is a marginal channel the Bunter Sandstone debris may either have been deposited by another advance of ice or by the washing out of higher level glacial deposits, with the limestone brash as an even more recent fluvial deposit. But so little is known of the detailed history of glacial events in this area that this idea can be accepted only with reservations.

An attractive alternative hypothesis takes more account of the pre-glacial drainage pattern. If a major consequent stream flowed through Ancaster at a level higher than the present Gap as believed by Swinnerton and Linton(5), the Gipple valley could be interpreted as a sub-parallel consequent joined to the Ancaster river by "The Valley" stream, that is, a short subsequent stream developed in the Great Oolite Clay which lies below and outcrops to the west of the low escarpment of the Great Oolite Limestone (Fig. 1). At some period in the Pleistocene the Ancaster Gap was deepened, most probably by the vast streams of water which must have run from the ice sheets in the summer months. Alternatively, overflow from glacial Lake Humber or Lake Fenland might have brought about this deepening. At the close of the Ice Age the Ancaster Gap was left without a major river and in the possession of the diminutive headwaters of the eastward-flowing Slea. Unable to keep pace in downcutting in the Ice Age, "The Valley" stream now vigorously attempted to grade its course to the new local base level. In the process it became a steep-sided, narrow-floored valley cut largely in Lincolnshire Limestone—hence its angular U-shaped form.

Further field work alone can prove whether "The Valley" is indeed a glacial channel or a normal, if rapidly cut valley. But there can be one definitive conclusion : an attempt to carry out geomorphological study in Lincolnshire startlingly reveals our ignorance of the evolution of the physical landscape of this part of the East Midlands.

(5) Swinnerton and Kent, op. cit., p. 145 and Linton D. L., "Midland Drainage", *Advancement of Science*, 7, 1951, pp. 449-456.

EAST MIDLANDS RECORD

THE EAST MIDLANDS EARTHQUAKE OF FEBRUARY, 1957.

The earthquake which occurred on the afternoon of February 11th 1957 in the East Midlands area literally shook many British people out of their belief that our islands are immune to such events. Earthquakes have, however, been recorded from this country at the rate of perhaps a dozen a year ever since accurate records were kept. The vast majority of these have been of slight magnitude and local in effect and have passed by with little or no general comment. The fact that this earthquake was the most intense felt in this country since the Colchester earthquake of 1884, and the most intense to be felt in the East Midlands since 1795 confirms the rarity of severe tremors and explains the interest aroused by this one.

The information which can be gathered regarding earthquakes comes from two main sources—instrumental and non-instrumental. The instrumental (i.e. seismogram) evidence in this case,(1) indicates the position of the epicentre as 52°50'N., 1°21'W., i.e. at a position three-quarters of a mile S. 40°W. of Castle Donington on a straight line from that village to Breedon on the Hill. The depth of focus (vertically below the epicentre) is more difficult to obtain, but a depth of approaching nine miles has been suggested. This should take one well below the Triassic rocks on which Castle Donington is situated and through any intervening Carboniferous rocks into the Pre-Cambrian Charnian rocks below. These Charnian rocks at their outcrop in Charnwood Forest are known to be traversed by several major faults and it is reasonable to suppose that the same is true beneath the Trias cover further north and that the tremor was caused by a movement along one of these faults. The movement would be slight enough not to cause the fault to break through the overlying rocks and appear at the surface. The timing of the main shock, on instrumental evidence, is given as 15h. 43m. 00s. G.M.T.

Non-instrumental evidence is less mathematical, relying as it does on personal observation, but can play an important part in the formation of estimates of the intensity of an earthquake at various localities. Dr. A. T. J. Dollar has collected information from a very wide area and the results of his researches are published in *Nature*, March 9th 1957. The most interesting of his findings are (1) that some 60,000 square miles of country was affected extending from West Hartlepool to Southampton, and from Aberystwyth to Diss, and (2) that the intensity centre lay in the neighbourhood of Diseworth at a point only 2½ miles S. 15°E. of the calculated epicentre.

My own enquiries have been aimed at obtaining the maximum amount of information possible concerning local effects. From the Chief Fire Officer, Derby Central Fire Station, I received details of 243 calls made by the Brigade to damaged property in Derby Borough, nearly all dangerous chimney stacks or dangerous masonry copings. A plot of the addresses on a street map of Derby revealed that most of the damage occurred in the older part of the city within a rectangular area, two miles by one mile, lying along an axis N. 30°W. on the SW. side of the

(1) Personal communication from E. Tillotson, Secretary, Seismological Committee of the British Association.

river Derwent. Proximity to the epicentre is obviously of secondary. importance to age and style of building in determining degree of damage

Insufficient information was forthcoming on direction of fall of chimneys for any sound deductions to be made as to direction of passage of earth waves, but I was personally impressed by the predominantly ESE. fall of all chimneys dislodged from six houses in the Macklin Street area. One very helpful letter from a former student of Derby College of Technology informed me that the light in his room was set swinging E-W, that a calendar on an E-W. wall was also set swinging violently and that a mirror on a N-S. wall was unaffected. Another letter which merits attention is one received from a Melbourne solicitor who was on the telephone to Nottingham at the time of the tremor and who experienced the vibration "a second or two before it reached Nottingham".

Regarding damage in other areas, a colleague at Loughborough College, Mr. W. Pegg, has collected information concerning his local area and tells me that of eleven cases of chimney fall all fell between due N. and N. 88°W., the direction of the epicentre from Loughborough being approximately N-W. A free pipe was set swinging in a direction N. 22°W. Several chimneys are reported dislodged in Nottingham and there was slight damage to older buildings in the city.

Possibly the most interesting of the local effects which have been reported was the accidental tripping of 17 electrical relays (designed for transformer protection at five Power Stations in the East Midlands area). These were at Castle Donington, Spondon, Willington, Ilkeston and Drakelow, respectively at distances of $1\frac{1}{4}$, $5\frac{3}{4}$, 8, 10 and 12 miles from the calculated epicentre. Work is at present in progress on this aspect of the earthquake which it is hoped may give evidence of the intensity of the earthquake at these points and of the influence of the geological character of the ground on seismic intensity.—G. LEES, Lecturer in Geology, Derby and District College of Technology.

INTERNATIONAL GEOGRAPHICAL UNION NEWSLETTER

The International Geographical Union (I.G.U.) was formed in 1922 with national committees of the adhering countries as its constituent members. The revival of activity following the second world war has resulted in a rapid and vigorous growth of the Union which now includes over forty adhering countries. Post-war international congresses have been held at Lisbon, 1949 (originally intended for 1948), Washington, 1952 and Rio de Janeiro, 1956. The next will be held at Stockholm in 1960. The Union publishes half-yearly in January and July the I.G.U. Newsletter, which includes articles, reports and other items of interest to professional geographers in either English or French. The Editor, who is also the Secretary-Treasurer of the Union, is Prof. Hans Boesch of the Geographical Institute, University of Zurich.

GEOGRAPHICAL ASSOCIATION CONFERENCE AT MATLOCK

The 1957 Spring Conference of the Geographical Association was held from April 23rd to 27th at the Training College, Matlock, under the joint auspices of the Departments of Geography of the Universities of Nottingham and Sheffield. Arrangements in the College were undertaken by the lecturer in Geography, Miss M. McAdams, while the meetings

were presided over by Prof. P. W. Bryan, President of the Association. Over 200 members, including a number of overseas visitors, attended the conference, one of the largest in recent years. Lectures dealing with aspects of the Peak District, the Matlock district and the industrial area of north-east Derbyshire were given by members of the staffs of the two Departments and others, while the Herbertson Memorial Lecture on "Major Natural Regions : Herbertson after Fifty Years" was delivered by Prof. L. Dudley Stamp in the Matlock Town Hall. In the course of the programme a good deal of time was devoted to excursions and field studies.